VOL. XXXI. — No. 5. MAY 1954.

Monthly Bulletin of the International Railway Congress Association

(English Edition)

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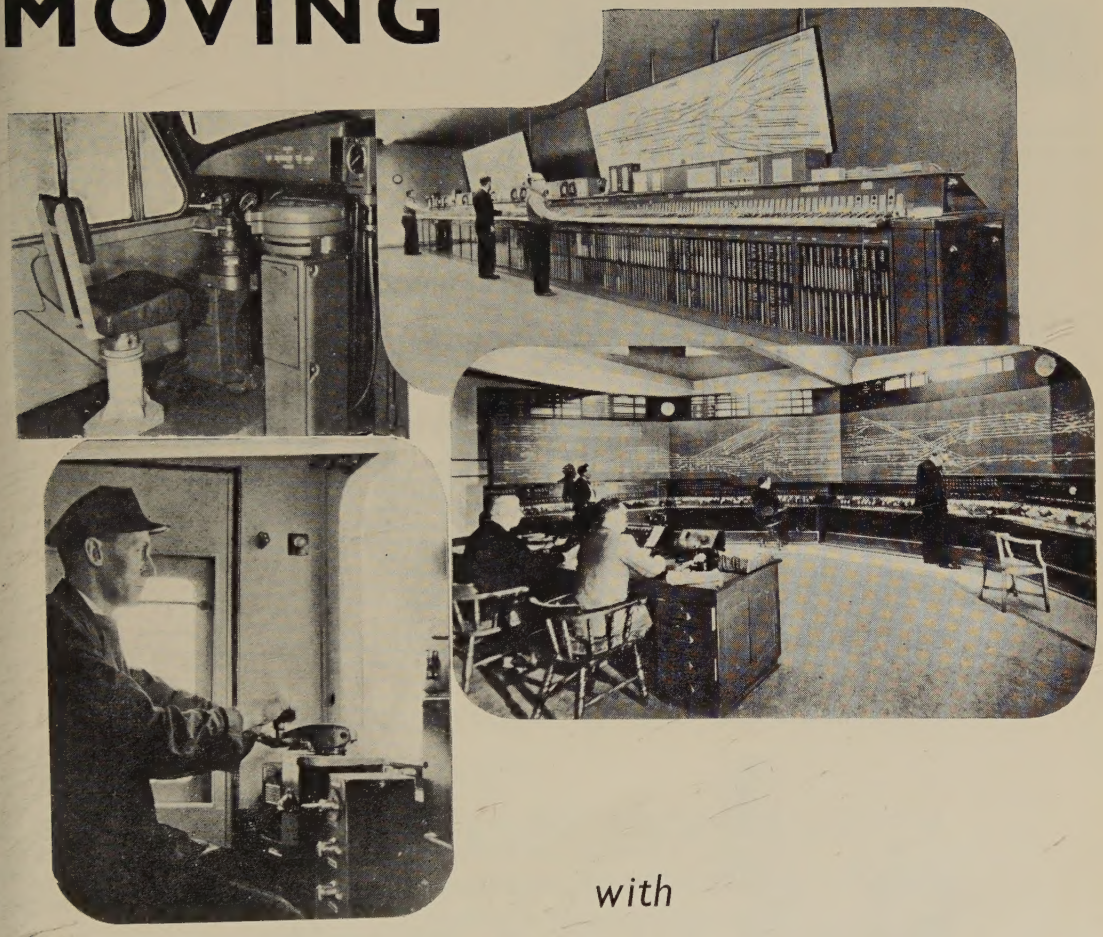

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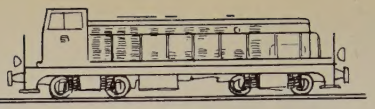

THE TECHNIQUE OF SINTERED PLATES
is being confirmed each day in many countries
by all the startings of Diesel locomotives
performed by S.A.F.T. batteries

EACH DAY UNDER ALL CLIMATES
the ruggedness of S.A.F.T. products is being demonstrated
by thousands of train lighting batteries in service

SAFT *is bringing a new contribution to Rail Exploitation with the*

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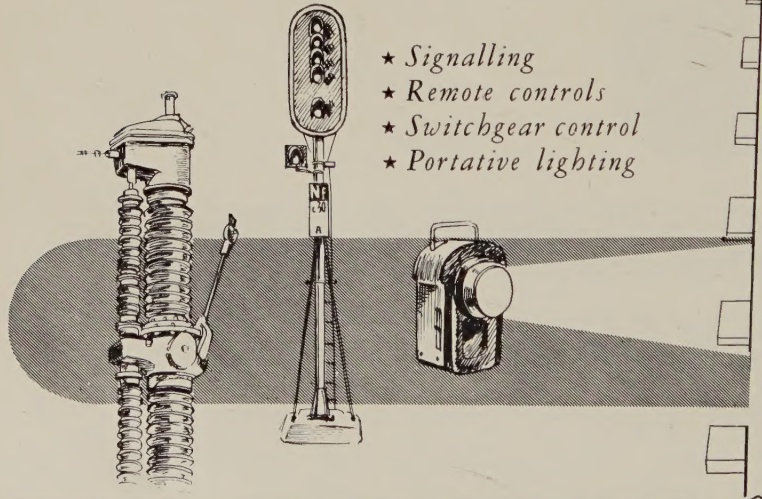
A storage battery operating

without giving of any gas
inside a hermetically sealed container

with the VOLTABLOC maintenance
obligations are over



- ★ *Signalling*
- ★ *Remote controls*
- ★ *Switchgear control*
- ★ *Portative lighting*

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1954

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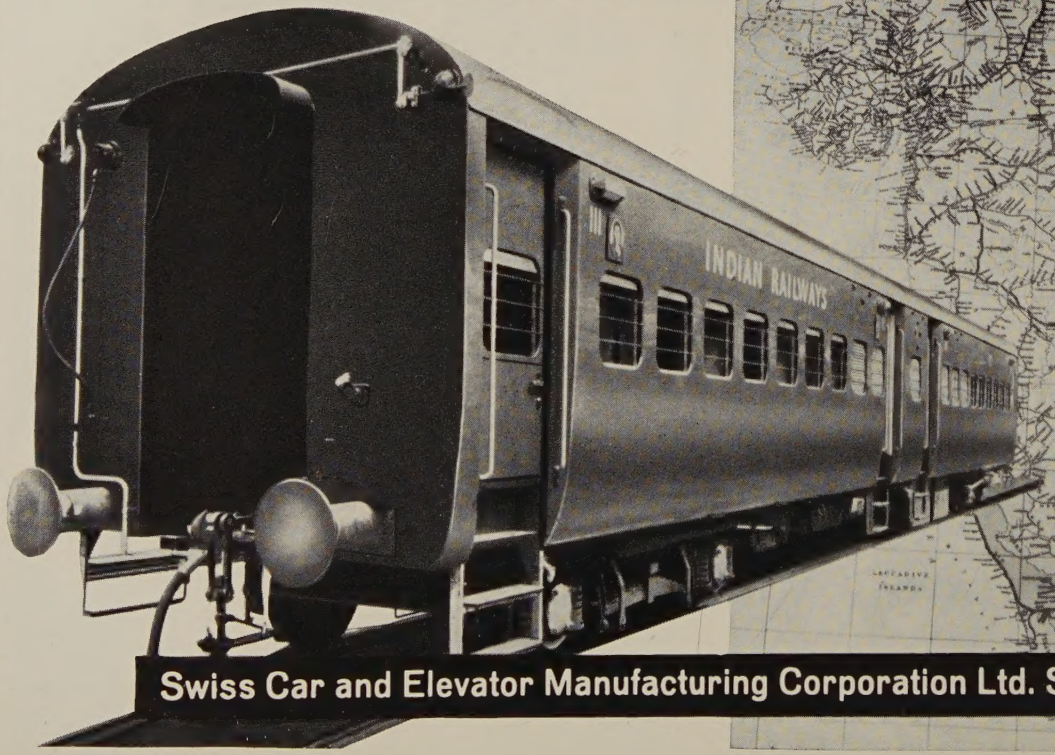
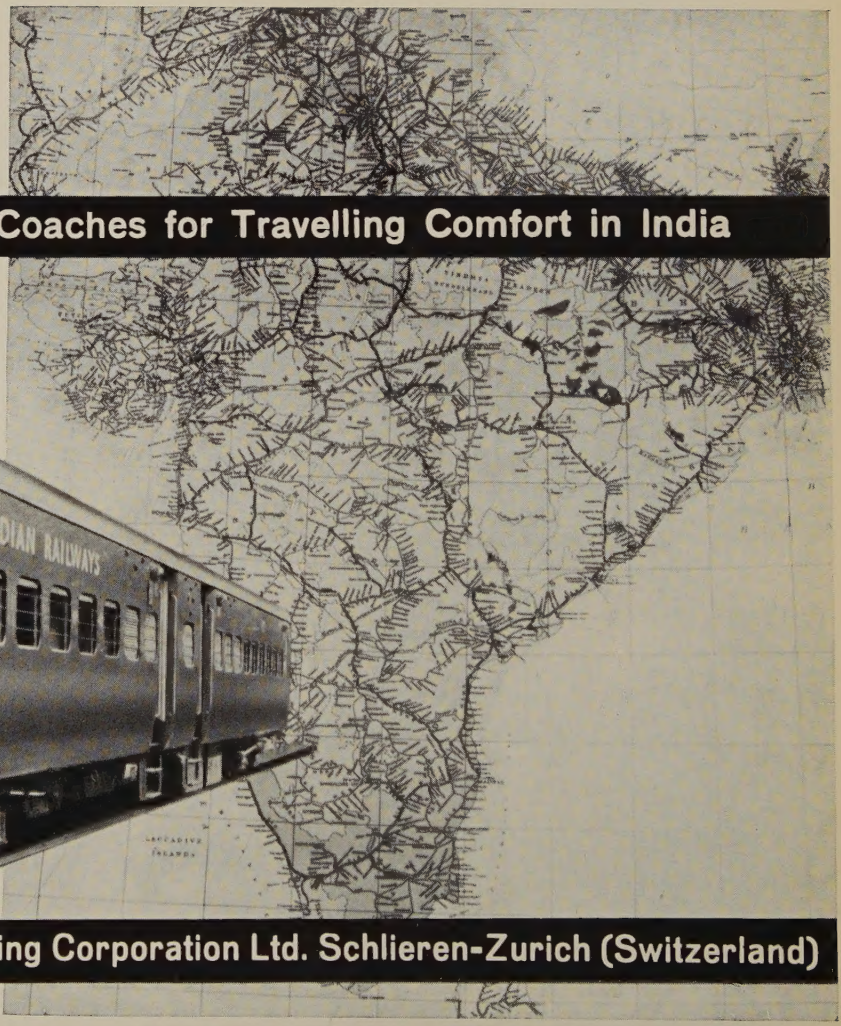
Schlieren Lightweight Steel Coaches for Travelling Comfort in India





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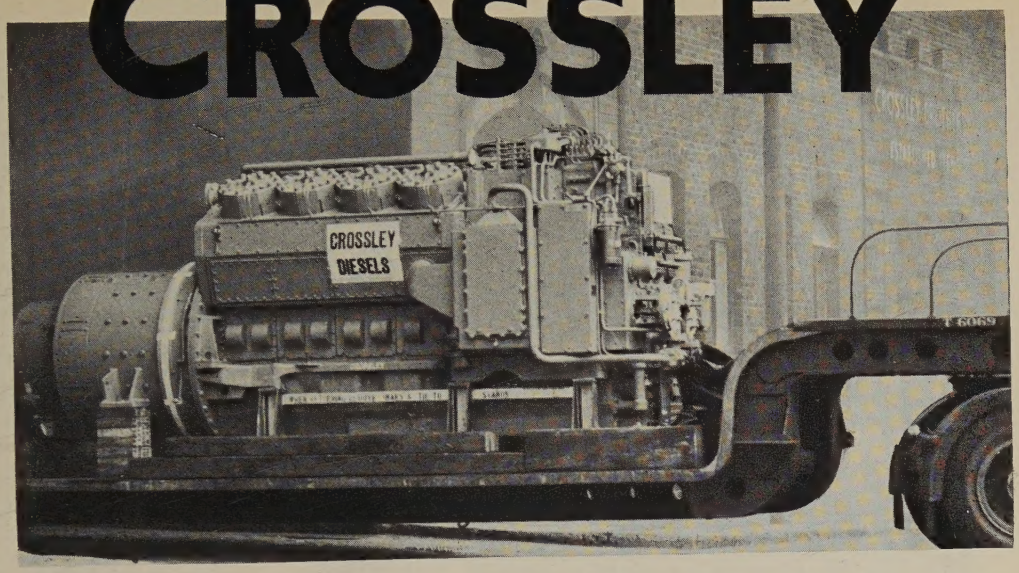


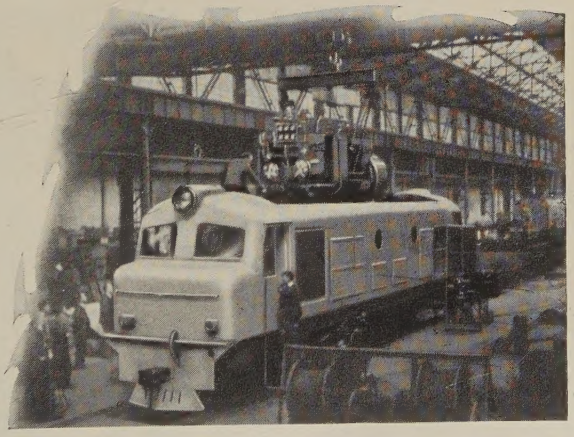
DIESEL ENGINES

— 48 DIESEL ELECTRIC LOCOMOTIVES — WESTERN AUSTRALIAN GOVERNMENT RAILWAYS

The engines are of the eight-cylinder Vee type with a service rating under site conditions of 1105 B.H.P. at 625 R.P.M. They are combined with a flange mounted Metropolitan-Vickers generator, the whole being carried on three-point rubber suspension.

The moderate operating speed, simplicity of port-controlled loop scavenge, ease of maintenance and high performance, provide an engine combining diesel economy with steam reliability

The illustrations show one of the sets leaving our works and, on the right, being lowered into a locomotive.



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C.366

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promote reliability

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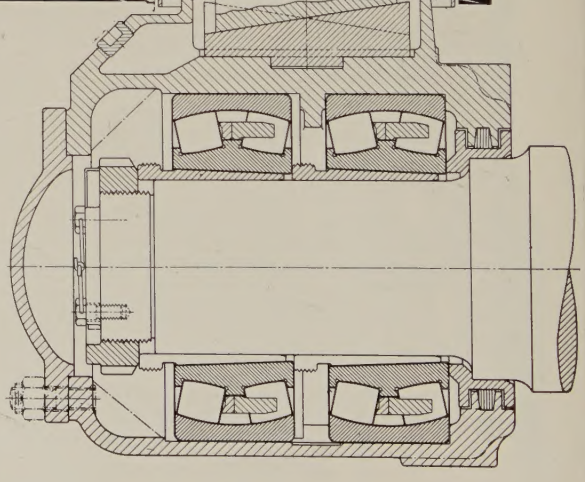

- Reliability, even at the highest speeds — no hot bearings.
- Saving of lubricant and of labour for lubrication.
- Lower maintenance expenses.

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GUARANTEED GLUING

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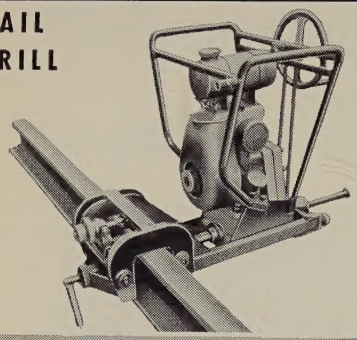
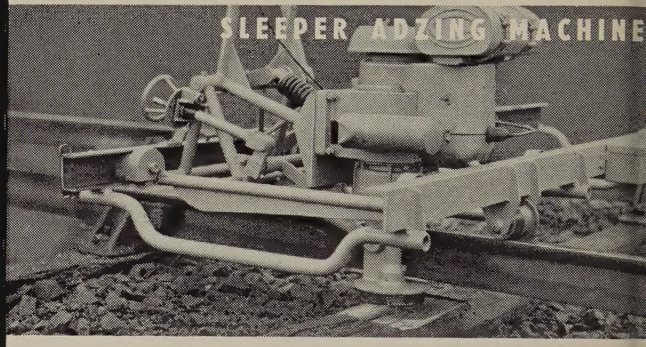
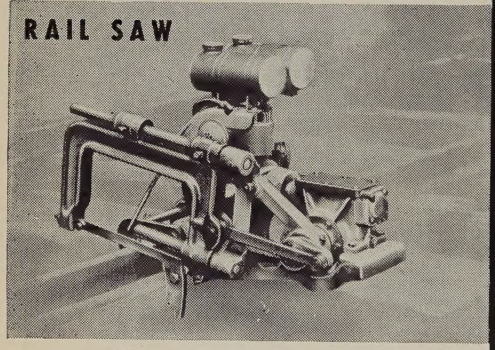


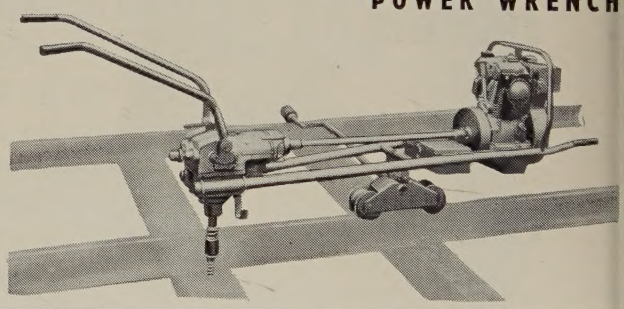
SLEEPER ADZING MACHINE

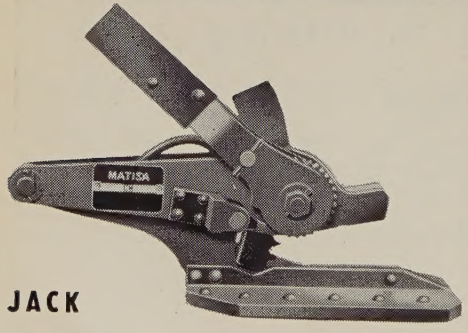


RAIL SAW

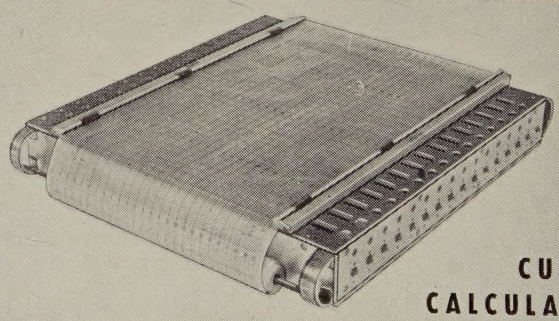


POWER WRENCH





JACK



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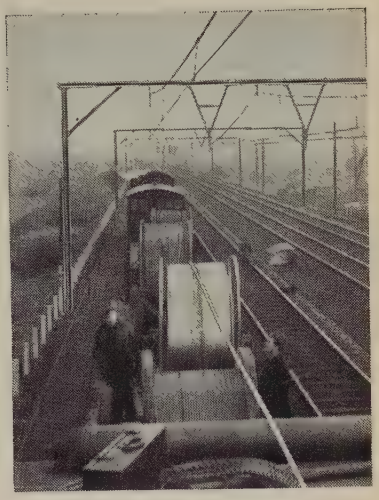
BICC SPECIALISE

n Overhead Equipment for Railway Electrification and Signalling Cables

Helping railways throughout the World achieve greater fficiency is one of the major activities of the BICC group. heir contributions range from the supply of specialised ables and accessories to complete electrification schemes. Ve show some examples of the tasks they undertake.



Track Electrification. Work in progress on the Liverpool Street-Shenfield line. Contact wire is being run out from a drum mounted on the wiring train.

Colour Light Signalling. Paying out signalling cable from ne cable drum. BICC produced the first length (3,500 yards) of luminium sheathed paper insulated cable for use solely for gnalling. It was used in the conversion to colour light sig- alling of the London-Brighton lines.

BICC overhead equipment between Wath and Dunford Bridge with an electric locomotive hauling loaded coal trucks.

Electrification can more than double the carrying capacity of a railway. In Australia, for instance, the volume of freight became too great for the important Sydney–Lithgow line, which crosses the Blue Mountains — so an electrification scheme was adopted. When completed it will enable double the freight tonnage to be transported *without additional reconstruction work*.

Similar advantages have been gained in England. Passenger traffic increased by over 50 per cent in two months on the Liverpool Street-Shenfield line after electrification. And on the route from Wath to Dunford Bridge two electric locomotives haul a laden coal train up a 1 in 40 gradient where previously four steam locomotives were required.

The BICC group designed, provided and installed the entire overhead equipment for these schemes. Other BICC services include the manufacture and supply of signalling cable of all types, rail bonds and cable accessories, and of course, the power feeder cables.

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Beyer-Garratt Locomotives
FOR
ECONOMICAL OPERATION BY STEAM
ONE HUNDRED YEARS OF
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LOCOMOTIVE DISTINCTION
The Beyer-Garratt Articulated Locomotive provides a solution to difficult operating problems. Suitable for all gauges and conditions.
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Double motor-coach.
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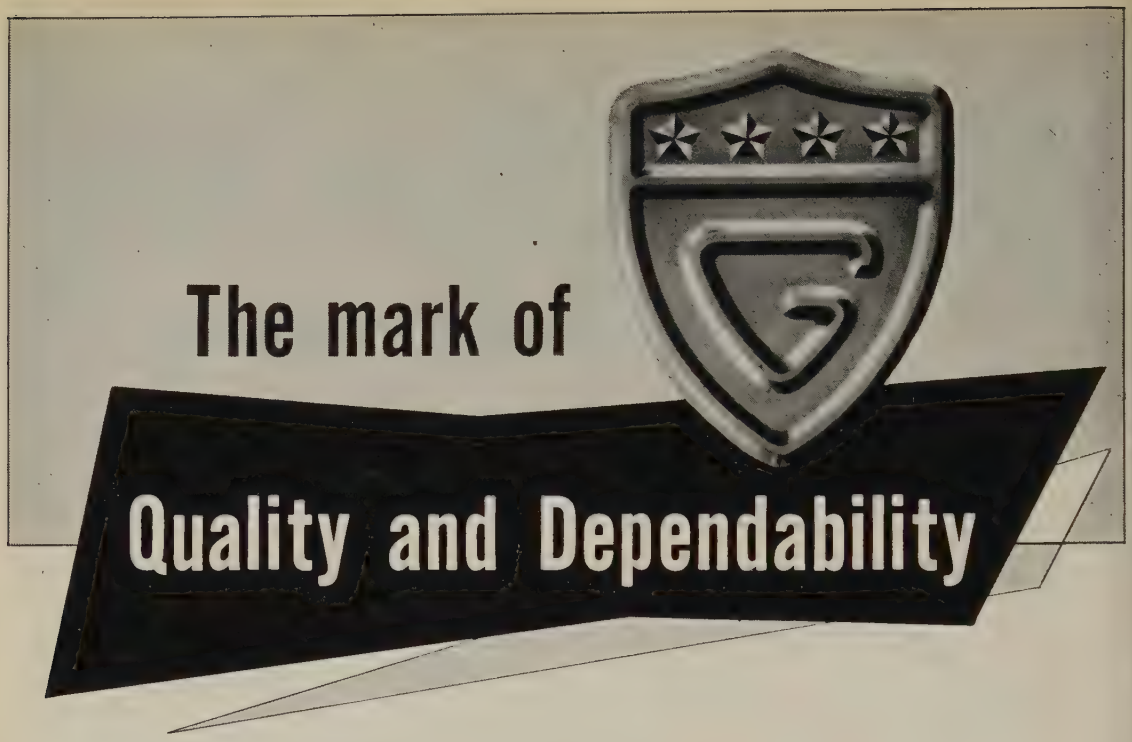

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Commonwealth Products other than beds are now obtainable from our licensees, English Steel Corp., Sheffield, England.

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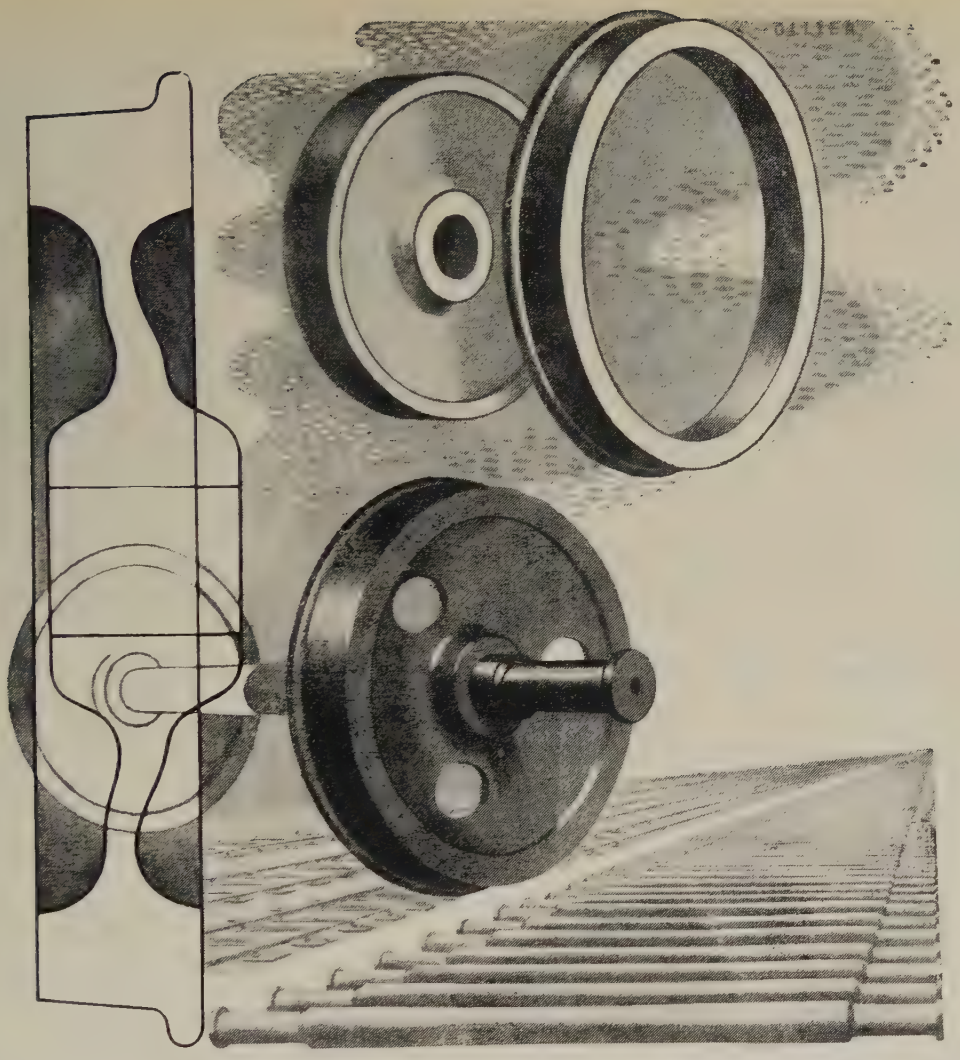

RAILWAY MATERIALS

The Steel Peech & Tozer works is famous for its steel tyres, produced for every kind of rolling stock up to the largest locomotive tyres. Notable are the unusually tough and hard-wearing 'CP' and 'BC' brands, and other specially-treated tyres, much esteemed by railway engineers in many lands. At this works are also produced rolled steel solid wheels, disc centres, locomotive carriage and wagon straight axles, locomotive crank axles and laminated springs.

At the Workington plant high duty wear-resisting Bessemer acid steel rails are made, together with fishplates, bearing plates and steel sleepers.

STEEL PEECH & TOZER · THE ICKLES · SHEFFIELD
WORKINGTON IRON & STEEL COMPANY · WORKINGTON
Branches of The United Steel Companies Limited of Sheffield, England

SP.133

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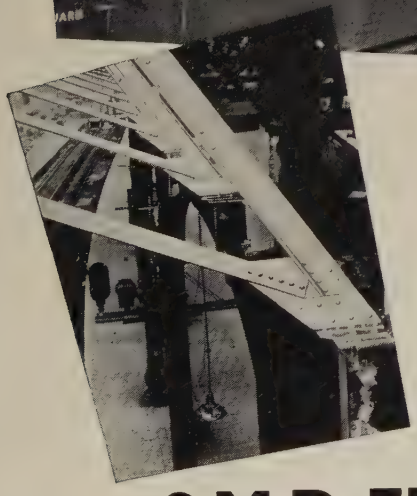
Société des Régleurs de Freins SAB — 64, rue de Rome — Paris

NEW ROOF
for London Bridge Station
in *Aluminium*



Aluminium was chosen for this important roof reconstruction contract because of its unique advantages, which include:

- **rapid erection**
- **light to lift and handle**
- **low loading on existing supports**

This advertisement appears by courtesy of British Railways and the Main Contractors Carter-Horseley (Engineers) Limited.

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IN ASSOCIATION WITH ALMIN LIMITED FARNHAM ROYAL BUCKS

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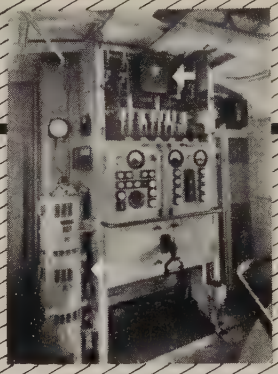
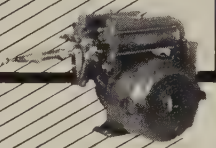
for Diesel-electric vehicles





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  for constant output of the Diesel engine
- Voltage regulators
  for auxiliary generators
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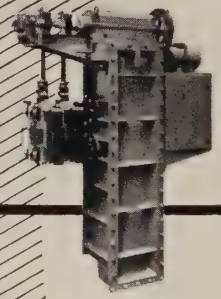
for 50-c/s, 15/25-kV traction vehicles



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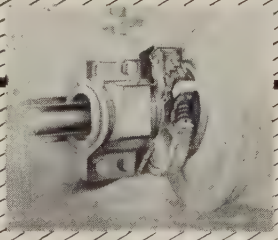
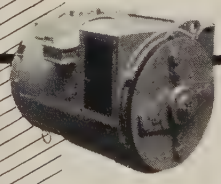
for all kinds of locomotives and motor-coaches





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- Disc drives

We can solve your traction problems

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Baldwin-Westinghouse Diesel-Electric Locomotives

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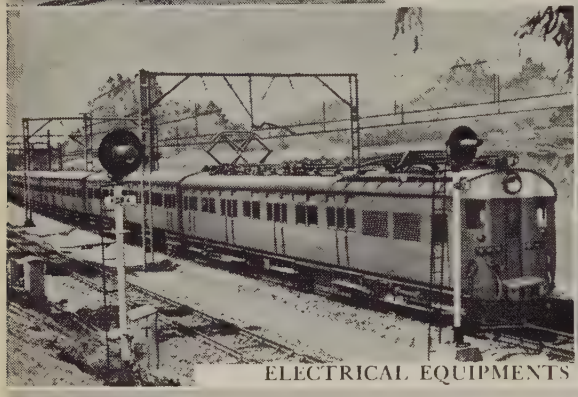
Traction Equipment for More Efficient Transport

ELECTRIC LOCOMOTIVES



ELECTRICAL EQUIPMENTS FOR MOTOR COACH STOCK

ELECTRIC LOCOMOTIVES AND GAS TURBINE LOCOMOTIVES

These illustrations give a small selection of the equipment supplied by Metropolitan-Vickers to meet the widest range of requirements.

50 years of experience in electric traction lie behind the craftsmanship embodied in the construction of these locomotives. Whether your problem concerns the choice of a gear wheel or a complete railway electrification scheme, the Metropolitan-Vickers organisation is ready to place at your service its technical competence and vast experience in traction matters.

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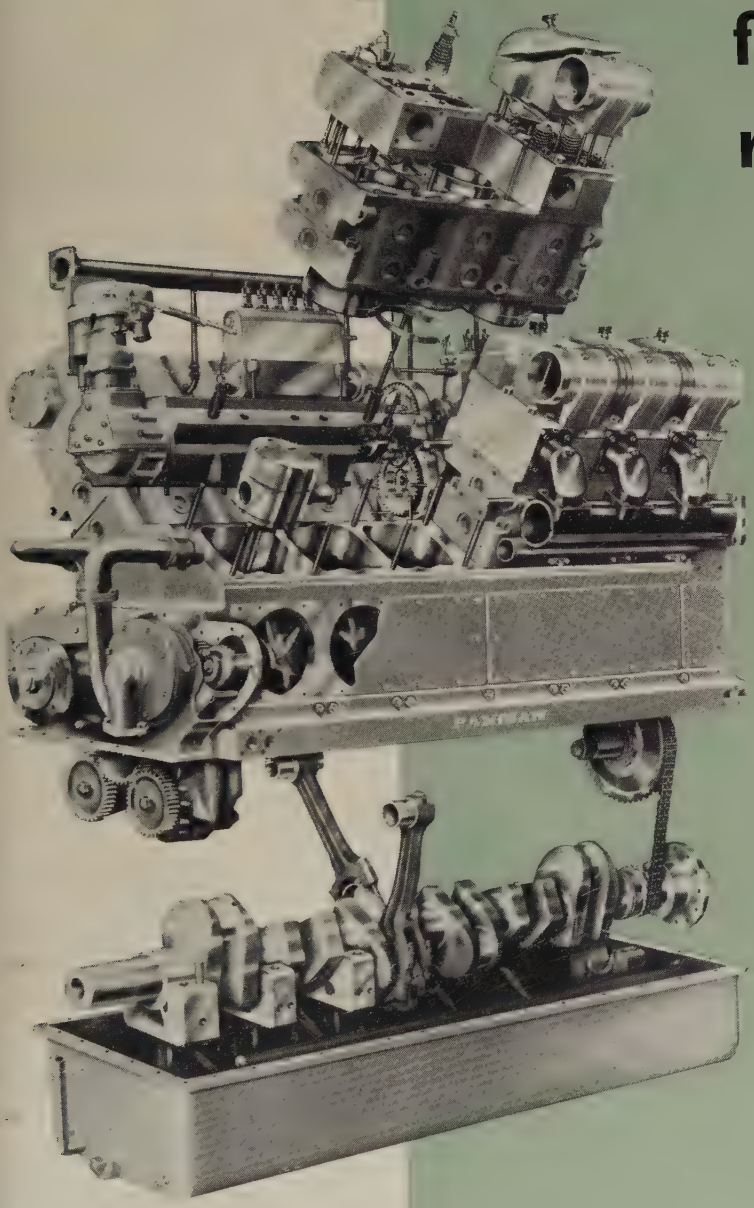
Member of the A. E. I. group of companies.

PAXMAN diesel engines for rail traction



An exploded view of the Paxman RPH Diesel Engine for Rail Traction Duty.

Paxman medium weight R.P.H. diesels for mixed traffic and shunting locomotives can be used for electrical, hydraulic or diesel mechanical power transmission. Especially suitable for locomotives with light axle loads, they are available with 4 to 16 cylinders in vee form, and have an output range of 133 to 833 h.p. in a speed range of 1000 to 1250 r.p.m.

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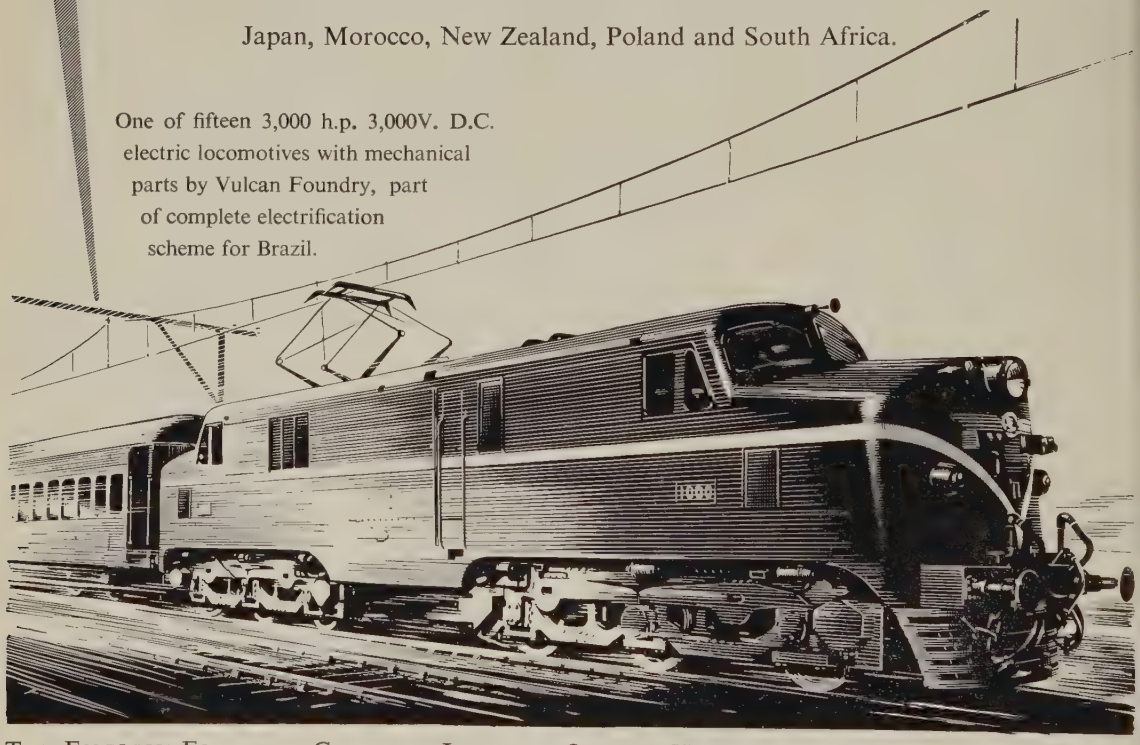
(ASSOCIATED WITH RUSTON AND HORNSBY LTD, LINCOLN)

'ENGLISH ELECTRIC'

Comprehensive Railway Electrification

'ENGLISH ELECTRIC' has very wide experience both in the design and manufacture of equipment for the generation, transmission, distribution and conversion of power for railway electrification. Complete schemes have been carried out not only in Great Britain but in Brazil, France, India, Japan, Morocco, New Zealand, Poland and South Africa.

One of fifteen 3,000 h.p. 3,000V. D.C. electric locomotives with mechanical parts by Vulcan Foundry, part of complete electrification scheme for Brazil.



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INTERNATIONAL RAILWAY CONGRESS ASSOCIATION
(ENGLISH EDITION)

PUBLISHING and EDITORIAL OFFICES : 19, RUE DU BEAU-SITE, BRUSSELS

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Orders for copies previous to January 1931 should be addressed to Messrs. Weissenbruch & Co. Ltd., Printers, 49, rue du Poinçon, Brussels.

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BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

SPECIAL ACCOUNTS

summing up the reports on the questions for discussion at the sixteenth Session of the International Railway Congress Association (London, 1954).

SECTION I. — Way and works.

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QUESTION 1.

What are the present tendencies relating to the organization of the maintenance of the permanent way : methods of determination of the works to be done and in particular, possibilities of the use of detecting-recording coaches, planning of the works, effects of mechanization ; importance of the side-tracks for the movement of the gangs and the mechanical devices.

Economic and financial aspect,

by Dr.-Ing. habil. Gerhard SCHRAMM,

Referent für Oberbau bei der Hauptverwaltung der Deutschen Bundesbahn, Frankfurt (Main).

Special Reporter.

Question 1 has been covered by the three following reports :

Report (America (North and South), Australia (Commonwealth of), Burma, Ceylon, Denmark, Egypt, Finland, India, Indonesia, Irak, Iran, Republic of Ireland, New Zealand, Norway, Pakistan, South Africa, Sweden and the United Kingdom of Great Britain and Northern Ireland and the territories for whose international relations the United Kingdom is responsible), by O. Hjelte CLAUSSEN. (See *Bulletin* for August 1953, p. 471.)

Report (Belgium and Colony, France and French Union, Greece, Italy, Luxemburg, Netherlands, Portugal and Colonies, Spain, Switzerland, Syria and Turkey), by C. FEYRABEND. (See *Bulletin* for December 1953, p. 993.)

Report (Austria, Bulgaria, Czechoslovakia, Hungary, Poland, Rumania and Yugoslavia), by Dr. Ing. habil. G. SCHRAMM. (See *Bulletin* for March 1954, p. 269.)

1. General.

The three reports by Messrs CLAUSSEN, FEYRABEND and SCHRAMM covered 42 Railway Administrations. These Administrations are listed in column 2 of the table below, classified according to continent and country. Columns 3 and 4 give — as far as such information was supplied by the respective Managements — the lengths of the railways in kilometres and the gross ton kilometres hauled annually. The lengths of the systems n give some idea of the importance of the railway from the point of view of permanent way maintenance technique, taking the lines into account according to their importance and also the track equipment. These are calculated as follows : i.e.

d = length of all the main lines in km;

e = length of all the other lines in km;

g = number of units of track equipment (sets of points).

The length of the system in km is therefore :

$$n = d + 0.3 \cdot e + 0.1\ g.$$

When the different railways are compared, it must not be forgotten that the methods and organisation of permanent way maintenance are more or less dictated by the following circumstances :

a) the length of the system;

b) the climate. In a mild climate, the maintenance work can be distributed evenly throughout the year. This is so in the southern countries and in the temperate zones, in the case of countries with a seaside climate. In places where the winter is severe or where there is heavy snowfalls, on the contrary, the work can only be carried out economically during the summer months, and the working season is only some 8 to 10 months long. This is the case in the northern countries, and in the temperate zone, in those countries with a continental climate. In addition, the useful life of the track depends to some extent on climatic conditions (humidity, dryness, heat, cold, xylophagous insects and plants, etc.);

c) the density of population plays an important part in the organisation of maintenance work. A local shortage of labour may make maintenance work more costly or make it necessary to go in for thorough mechanisation;

d) the kind of population and its standard of living play a considerable part, especially as regards the possibility or necessity for mechanisation. The using and maintaining of machines imply workmen who have had a certain amount of mechanical training. If this is so, it is easier to go in for mechanisation and the results obtained will be better than in districts with a primitive populace. On the other hand, in such places with a primitive population, employed at low wages, the need for mechanisation will be less than in the case of a highly civilised population earning high wages;

e) the economic structure of the country. In this field, it is above all the cost of the materials used for the permanent way and transport conditions that play the essential role.

As Railway Managements differ considerably as regards all or some of the above mentioned circumstances, the results of the enquiry, applicable to certain managements, cannot be generalised purely and simply for all railway administrations. In addition it must not be forgotten that :

On many Railways, development has been more or less irregular during the past twenty years, on the one hand owing to the war, and on the other by reason of the modifications made in transport owing to the growth of motor and air traffic. The war often led to a shortage of materials and labour and the railways were exceptionally neglected. The ever increasing competition of motor transport resulted on the other hand in a reduction of the receipts which in its turn affected the possibility of maintaining the permanent way. As a result, on many Railways there is a very wide gap

RECAPITULATION.

Table giving the Railway Administrations covered by the reports.

1	2	3	4
N°	*Administration*	*Length of system km*	*TKBR per annum in millions*
	EUROPE		
1	*Belgium :* Société Nationale des Chemins de fer belges	12 899	28 143
2	*Denmark :* Danish State Railways	4 871	7 725
3	*German Federal Republic :* Deutsche Bundesbahn	70 300	173 900
4	*Finland :* Finnish State Railways.	6 545	—
5	*France :* Société Nationale des Chemins de fer français (S.N.C.F.).	82 461	180 000
6	Société Générale des Chemins de fer Economiques . . .	1 787	230
7	Régie Autonome des Transports Parisiens	—	—
8	*Greece :* Greek State Railways	1 522	1 307
9	Thessalian Railways	225	32
10	*Great Britain :* British Railways	80 279	—
11	London Transport Executive	966	—
12	*Republic of Ireland :* Coras Iompair Eireann.	2 997	—
13	*Italy :* Italian State Railways	26 446	56 830
14	*Luxemburg :* Chemins de fer Luxembourgeois	802	1 476
15	*Netherlands :* Netherlands Railways	6 532	18 000
16	*Austria :* Oesterreichische Bundesbahnen	10 100	19 200
17	*Portugal :* Portuguese Railways Cy	4 308	3 580

Table giving the Railway Administrations covered by the reports. *(continued)*

1	2	3	4
N°	*Administration*	*Length of system km*	*TKBR per annum in millions*
	Sweden :		
18	Swedish State Railways	17 051	33 091
19	Nora Bergslags Railway	220	82
	Switzerland :		
20	Swiss Federal Railways	6 600	17 485
21	Rhätische Bahn	526	269
	Spain :		
22	Red Nacional de los Ferrocarriles Españoles	17 735	30 576
23	Catalantes Railways	196	168
	ASIA		
24	Syrian State Railways	275	38
25	Ceylon Government Railway	1 779	—
26	Régie des Chemins de fer non concédés du Viet-Nam.	997	388
	AFRICA		
27	Egyptian State Railways	6 030	8 200
28	Office des Transports Coloniaux (O.T.R.A.C.O.)	529	1 400
29	East African Railways	—	—
30	Rhodesia Railways	2 464	10 093
31	South African Railways	25 710	65 357
32	Sudan Railways	3 585	—
33	Algerian Railways	5 147	4 534
34	Gafsa Railway	515	1 090
35	Tunisian Railways	1 754	992
36	French Equatorial and Cameroons Railways	564	308
37	French West African and Togo Railways	4 178	1 560
38	Franco-Ethiopian Railway	824	400
39	Madagascar Railways	944	88
40	Moroccan Railways	1 761	3 650
41	Nigerian Railway	287	118
	AMERICA		
42	Association of American Railroads	—	—

between the maintenance work which would normally be carried out to assure safety of working, and that which could be carried out with the financial means available. From the point of view of permanent way maintenance, such Railways are no longer in a state of equilibrium, but they must endeavour to regain such equilibrium and adapt themselves to the limited funds available. They are endeavouring to do so by making certain modifications in the organisation of permanent way maintenance work and by extensive mechanisation of the work. These two measures have as their object a reduction of the cost of maintenance work to the greatest possible extent. The Administrations concerned are therefore at the present time in a state of reorganisation, which will last for some years. It is precisely on this account that the reports for this year's session of the Congress are of such importance, although no final conclusion can at times be arrived at.

Another consideration which must be taken into account in comparing the reports is the vagueness of what is meant by « maintenance ». In its widest meaning, it covers all the work which serves to keep the system in such condition that safe working is assured, i.e. the whole of *all* work on the permanent way. But, in a narrow sense, it can be taken to mean only the small jobs undertaken between important permanent way work (laying of rails and sleepers over long sections and complete track equipment). Taken in this way, maintenance consists above all in such operations as restoring the level, layout and gauge when these have deteriorated under current use. In addition, the idea of maintenance is also used in the purely financial meaning as the opposite to *renewal* (for example on the Deutsche Bundesbahn). This latter includes all work in which new track equipment or new rails and sleepers are laid over distances of more than 100 m. It is then said that there has been a renewal of the track equipment, of the running line, of rails, sleepers or ballast. All other operations, on the other hand, are counted as maintenance.

In studying the organisation and mechanisation of permanent way work, the idea of maintenance should not be taken in too narrow a sense, as from the point of view of the use of labour, its distribution into gangs and mechanisation, it is of little account whether old or new materials are being used, whether it is a simple tamping job or whether at the same time rails and sleepers are being replaced. We are therefore not going to limit our examination to maintenance in the narrow sense of the word, but will deal with all work on the permanent way in general.

2. The allocation of labour in the maintenance of the permanent way.

The labour employed by the permanent way department is used by priority for the maintenance of the track and its bed. However, on nearly all railways, it is also used for other objects, for example, level-crossing keepers, signalmen, in conjunction with operating and traffic requirements, in stations, in traction establishments, etc. The crossing keepers and signalmen are usually permanently occupied in their boxes and consequently should not be considered as permanent way maintenance staff properly speaking, although they are attached to definite sections of line. However, when they have to be replaced for reasons of sickness or holidays, their jobs are taken over by men from the platelayers gangs.

On many Railways, the extra labour required by the operating, traffic, etc. departments is not filled from the maintenance gangs and any gaps are made good in the actual stations. This is the form of organisation which in general is aimed at nowadays for the following reasons : the supplying of extra labour to other departments means unforeseeable variations in the strength of the gangs. When the staff was numerous and the maintenance work was all done by hand as in the past, this was not too serious. But with the reduced labour force of today and highly mechanised state of maintenance work, such fluctuations in the available labour make the

work extremely uneconomic. In the case of mechanised gangs, all the men are allocated to definite duties. Consequently, the output and user of the machines and tools falls immediately to a very serious extent as soon as labour is borrowed from one of these specialised gangs. The growing mechanisation of permanent way work will therefore automatically lead to the permanent way department no longer having any commitments as regards supplying labour for the operating department, though this does not mean that in the future the men cannot be transferred if they wish from the permanent way maintenance department to other departments. It is necessary, however, to have well trained men for the permanent way work. This is only possible if the men and their supervisors are considered and paid in accordance with the difficulty and responsibility of their job. Attempts are being made to do this. For example in the future on the Deutsche Bundesbahn some of the gangs will consist of « qualified platelayers (Gleisbauer) able to qualify for promotion to the grade of permanent way supervisor (Gleiswerkmeister) ».

The supervision of the lines is always the responsibility of the permanent way maintenance staff. The frequence of their inspection tours varies from railway to railway from once a day to once a week; important railways (for example the S.N.C.F. and S.N.C.B.) are content with one tour per week, which seems to show that — at least under the conditions prevailing in Europe — daily inspection of the lines is not necessary on either main lines or secondary lines. The regulations regarding the frequency of inspection tours date from other days when there were no such frequent train services, the telegraph and telephone systems were not so highly developed nor were there service trollies of the type used today.

3. Transport of labour for permanent way maintenance to the place of work.

The situation varies considerably according to the density of population and the standard of living. In regions with a very dense population, the workmen can usually get to work on foot or by train. In regions with a very scattered population, the distances they have to cover are often considerable. Some Administrations pay a small travelling allowance. The bicycle is widely used in Europe (for example in Belgium, Denmark, German Federal Republic, France and Holland). Some Managements are considering transporting most of their labour by trolley in the future. In the United States, the motorcar is as important as the bicycle in Europe, and just as widely used.

It is extremely rare for the men to be able to have lunch at home. They usually bring their provisions with them, and have a break of 1/2 an hour to 1 hour for lunch. In a few cases, members of their family bring their meal out to them at work. The men living in work trains get their lunch on the train.

As in districts with a very sparse population, there are sections of line where there are not sufficient men for the carrying out of large permanent way works, certain Administrations have *special work trains* complete with sleeping quarters, washing facilities, kitchens, workshops, etc. These work trains have the additional advantage of providing well trained staff. They are therefore particularly useful for laying track equipment. Against these advantages must be set the cost of running the train, the kitchen, etc. However, provided such trains are well used and if the organisation of the work is good, work trains are the most economic solution. The Deutsche Bundesbahn for example has 73 such trains, with a staff of 80 per train, and 6 training trains for gang foremen, each taking 40 men, in which candidates get their theoretical and practical training into permanent way work. In regions where there is heavy snowfalls, the track laying trains are wintered in the large stations and used for clearance work if necessary. In addition, the personnel is occasionally used in the winter for work in the sheds or other such work.

Most Railway Administrations do their permanent way work with their own staff; only a small number call in contractors to any extent.

4. Determination of the work to be carried out.

The simplest part of permanent way maintenance work is the tightening up of coachscrews, tamping of individual sleepers, etc. We call this *small maintenance*. During this work, the bed is not altered in any way and, in general, no materials are replaced. The next degree of permanent way work is *overhaul*. This may cover either the whole of the track or be limited essentially to the joints; in the latter case, it may be called *partial overhaul* or maintenance of the joints. During the overhaul, certain material is also replaced (rails, fishplates, bolts, sleepers), usually from recovered materials. If the wear is such that an overhaul can not restore the track to the desired state of repair, the material has to be replaced (rails and small material, sleepers, ballast) over long continuous lengths. According to whether new or recovered material is used, this is called *renewal* or *replacement* (renewal of the track, replacement of the track, renewal of rails, replacement of sleepers, renewal of ballast, etc.).

The economics of permanent way work is to carry out in each case the work which, in the end, will lead to the minimum of current expenses. The essential consideration from this point of view is naturally the condition of the layout and the permissible load on the track. These depend on the speed of the trains, their axle loads and their number (annual load on the line in TKB).

The layout of the line and its condition have to be estimated by the supervisory staff from their practical experience. As regards the layout, certain measurements are necessary. These are a lengthy job and not always very reliable when carried out by hand over long sections. This is why for the last 50 years attempts have been made to build vehicles which will give by means of a diagram an accurate picture of the state of the track. The condition of the track cannot, it is true, be determined directly by means of such vehicles (rotting of wood sleepers, rusting of metal sleepers, loose coachscrews, wear of rails and small material, etc.). However, the condition of the track as shown on the recording diagram can be deduced to some extent. A relatively widely used vehicle is the *Dorpmüller measuring apparatus* fitted on a trolley which is pulled along the track by two men. It records on a band the relative level of the rails (superelevation) and the gauge. Its chief defect is that it gives no idea of the curvature conditions and its measuring speed is slow. For this reason, the Deutsche Bundesbahn is now studying a *recording vehicle* which will also give a diagram of the versines (diagram of the curvature) and, for each rail, a curve showing low joints. This will be used in particular for passing work carried out on the track. About 25 years ago, certain European and American railways designed recording vehicles which are hauled by a locomotive at a fairly high speed and record the layout of the track much better than the Dorpmüller apparatus, under a considerable axle load (8 to 10 t). For example, there were the inspection wagon of the Swiss Federal Railways, the Hallade and Mauzin wagons in France and the control wagon of the Deutsche Bundesbahn. Whereas in the case of the first two the records are somewhat influenced by the speed, in other words by the dynamics of movement, the two latter in every case record nothing but the actual layout of the track, quite independent of the speed. The German control wagon records the following curves on its record band :

1) superelevation curve (relative level of the two lines of rails) to a scale of 1 : 5;

2) curve showing low sleepers (low joints) for both lines of rails to a scale of 1 : 1;

3) the gauge to a scale of 1 : 2;

4) diagram of the versines (diagram of curvature) for the two rails (versines corresponding to a chord of 20 m [22 yards approx.] at a scale of 1 : 5);

5) direction curve (curve of the combined versines);

6) for each line of rails, a curve showing any undulatory wear;

7) curve showing the kilometric distances.

There are therefore altogether 10 curves on the record strip. The recording wagons, by means of which all the main lines are recorded at intervals of 2 to 4 years, provide by their records a sure basis for the evaluation of the layout of the track, and an invaluable criterion for the determination of the maintenance work required. The Dorpmüller apparatus is hardly used any longer except for the passing of work done. On many Railways, overhauls used to take place at certain predetermined intervals over long sections of line. The increasing financial difficulties of the railways however obliged them to give up this methodical overhaul and to limit overhauls to the absolutely indispensable limits or content themselves with a reduced overhaul confined essentially to the overhaul of the joints.

5. Mechanisation of permanent way maintenance work and its influence on the organisation of the work.

A great many railway managements are extending mechanisation of permanent way work at the present time. This evolution may come to a halt in a few years. In general, the machines are the more economical as they are the larger, more powerful and better used. But the large machines (for example tamping machines and ballast screening machines running on rail) can only work on a line closed to traffic. The closing down of a line, putting the machine into position on the line and then removing it before the line is reopened to traffic all involves a loss of time. The maximum economy is therefore obtained by closing the line to traffic completely for as long a period as possible. However, this is not possible on lines with particularly heavy traffic. On most double track lines, however, experience goes to show that single track working can be organised over sections of several kilometres for a week or two. Such measures will be greatly facilitated and made more economic if the track equipment and signals of the double track are so organised that it is possible at any time to organise single track working on one or other line. It would be as well to go into this point when considering the renewal of track equipment and signals.

The final degree of mechanisation will differ on the various railways according to actual conditions. For example, mechanisation cannot be carried as far in Europe as in the United States where wages are relatively much higher. The state of mechanisation can be measured by dividing the total HP of the permanent way machines — including those of the sheds — by the number of men employed on the line. Total mechanisation will be found to vary according to circumstances from 1.5 to 3 HP per man.

At the Madrid Session in 1930, it was already noted that the progress of mechanisation would make it essential to reorganise permanent way maintenance work and the reports for the present Congress again stress this point. The following three measures constitute the essential preliminary conditions if mechanisation is to be a financial success :

1) well trained gangs, familiar with the working of the machines and not weakened by the withdrawal of labour for other purposes;

2) the transport of the men by trolleys or road motor vehicles, or lodging them in specially arranged wagons;

3) the maintenance of the machines in special depots, specially organised for this purpose, where skilled labour is available.

When motor driven machines are used on lines open to traffic, it is usually neces-

sary to take additional safety precautions to prevent accidents if the men are to work in safety. In the case of certain machines which can travel on the track, it may be asked whether these should not be used only on lines closed to traffic, if, from the operating point of view, they are to be treated as trolleys or if they should be used with lookout men, and in this case, what safety measures should be taken.

6. The importance of paths for the maintenance of the track.

Regarding paths, conditions are extraordinarily diverse on the various railways. In Europe, there are as a rule such paths; their width varies between 0.50 and 1 m (1′ 7 3/4″ and 3′ 3 3/8″); though they are often narrower alongside secondary lines and in mountainous regions. The use of such paths for the transport of machines is often interfered with by the mileposts, signals, signal-cables, posts for the overhead wires, gradient signs, etc. Such obstacles also interfer with the work of ballast screeners. Consequently attempts are being made to remove all such obstacles from the paths and to widen them as much as possible. In regions with a small population, there is often sufficient room alongside the track, or there are lateral roads, so that machines can be transported without difficulty. It is the same, for example, on most railway lines in the United States.

7. Economic and financial considerations.

There is no doubt that mechanisation of permanent way work is advantageous in all cases. However, the most economic degree of mechanisation depends on prevailing conditions, especially the ratio between wages and the costs of permanent way materials, the machines and the materials they use. From this point of view, mechanisation is the most economical in the United States. In this country, mechanisation has made it possible to reduce labour costs for track maintenance to about one half in the last 22 years. On the European railways, it is not possible to achieve such a reduction in the cost of labour; it might be reduced by about 20 %. The costs of maintaining the permanent way given by the various railways can seldom be compared, because they refer sometimes to the actual maintenance, and sometimes to all work on the permanent way. In addition, the difference between work normally necessary and the work limited by financial difficulties also comes into play. Certain Railway Administrations have some of their work done by contractors; however, taking the railways as a whole, the proportion of work done by contract is small.

Apart from the mechanisation and reorganisation of permanent way maintenance, the following influences are likely to be of particular importance as regards the economic aspect of permanent way maintenance in the future :

a) *Concrete sleepers.*

During the last 20 years, various types of concrete sleepers have successfully been designed to meet all requirements. This is thanks to the technical progress made with reinforced concrete (high class steel, high class cement, vibration, prestressing). The economic value of concrete sleepers depends above all on their price and their useful life compared with wood sleepers. As the prices vary from one country to another, the economic value of concrete sleepers will be variously estimated by the different Managements. At the present price of wood sleepers, track laid on concrete sleepers will cost rather more than track laid on wood sleepers. However, the former will result in considerable savings in the future if its useful life is longer than that of track laid on wood sleepers. From experience to date, this is a certainty. Trials are also in hand to prolong the life of wood sleepers by improving the methods of impregnation.

b) *Track welded into continuous lengths and welded groups of track equipment.*

Although for many years theoretical stu-

dies have led us to believe that a well ballasted track on the straight or without any too pronounced curves, could not become deformed under the action of thermal stresses, till recently no one risked laying any such lines. Up to 1950, there were only a few experimental examples of continuous welded track. Track laid on concrete sleepers offers exceptional security against deformation owing to its greater weight and particularly solid bed. For this reason the Deutsche Bundesbahn, profiting by the ever increasing use of concrete sleepers, began in 1950 to make a large scale use of continuous welded rails; to date about 2 000 km (1 242 miles) have been laid in this way. Welded rails may be 8 km (5 miles) long. Owing to the solid way the rails are fastened to the sleepers, stresses due to heat and cold do not lead to any movement of the ends. Consequently expansion joints have not been used at the ends of welded rails, but only a certain number of anti-creep devices. Welded track costs about 700 DM per km less than track laid with 60 m (196 ft.) rails. To this must be added appreciable maintenance economies, because there is none of the cost of maintaining the joints, which costs about 8 % of the total maintenance figures in the case of ordinary track. On the S.N.C.F. the track is welded into sections 800 m (2 624 ft.) long, and simple expansion joints are provided at the ends, the cost of which amounts to about the same as 4 m (13 ft.) of track. In the United States also, welded track has been increasingly used in the last few years.

Nowadays, especially in marshalling yards, a large number of complete sets of track equipment are welded, which reduces maintenance costs and improves the running of the wagons.

c) *Building up by welding.*

This makes it possible to do away with the hollows caused by shocks which appear in rails and track equipment, and to build up the frogs, etc.

d) *Restoring rails by planing or grinding.*

Worn rails that have been taken up can be machined by means of planes or special rectifiers in such a way that their running surface becomes perfectly smooth and — apart from vertical wear — they are equal to new rails. Rails removed from the main lines with heavy traffic owing to defects in the running surface can be relaid a second time in lines of the same category after they have been renewed, whereas formerly it was only possible to use them on lines of a lower category.

Summaries.

1. — The maintenance work of the length gangs varies in different Railway systems according to circumstances such as climate, density of population, wages, social and economic conditions, cost of materials, living standards, etc.

2. — Until recently the permanent way gangs have generally been organised as short length gangs responsible for the entire maintenance work of the track length in question (supervision, maintenance work proper, as for instance levelling, lining, gauging, weed killing, etc.) and various other works of local character, such as relief of permanent level crossing keepers.

3. — If the situation due to the development of other kinds of transport has reduced the traffic on certain secondary lines, the fight against such competition has led, in order to reduce the working costs, to run over most other routes heavier and heavier wagons hauled by engines on which the weight on the driving axles has tended to increase more and more, whilst the actual speeds have become higher and higher.

4. — Especially in countries where increasing wages have made it necessary to get the very most out of the working power, trials have successfully been started with longer gang lengths or with mobile gangs in connection with reduced local gangs.

The introduction of such gangs permits :

a) the reduction of the number of gangers as well as of the supervision personnel and better organisation of the work;

b) the extension of mechanisation;

c) the specialisation of the gangers;

d) the production of more uniform and probably more durable work;

e) the greater ability for the gang to carry out major items of track work.

5. — The determination of the maintenance works to be done has for many years generally been based on :

a) the experience of the durability of the work under the local conditions involved (predetermined cycles). This depends partially on an estimate and can vary much from place to place;

b) the very careful examination in the field of the track (systematic surveys). These surveys are complicated and take much time;

c) the appearance of trouble in the track. When this takes place defects may be so developed that they are beyond repair.

6. — *a*) After recognising the insufficiency of the « stitch in time » method for assuring the proper condition of the permanent way, certain railways have adopted a general overhaul method covering the whole system, which is unnecessarily costly.

The introduction of methodical maintenance covering a periodic general overhaul and a limited overhaul to deal with level, especially at the joints, and tightening up the fastenings, has resulted in considerable savings, especially from the labour point of view.

b) The necessity for maintenance operations is no longer based on a simple estimate of the actual condition of the track, but chiefly on an estimate of the probable rate at which it will wear.

There will be considerable saving due to the reduced mileage to be dealt with, a better definition of the elementary work, and a reduction in the number of intermediate overhauls.

7. — Recording vehicles, particularly those which give an exact position of each rail in the vertical and horizontal planes and their exact gauge, give invaluable services from this point of view, with regard to the factors to which they are sensitive. By the comparison of successive recordings they make it possible to follow the evolution of the condition of a given line.

The use of recording vehicles is of very great economical value, because it permits the maintenance work to be done exactly on the right spot and just at the right moment, with consideration to the track-standard of the entire railway system.

8. — As well for economic as for technical reasons it is of the greatest importance that planning of maintenance works be done under close collaboration between maintenance and operating officers to establish appropriate speed restrictions or the diversion of traffic to other lines or tracks, with due consideration to the traffic and to the type of work involved.

9. — The mechanisation is especially advantageous with larger gangs and contributes greatly to the success of the above mentioned trials. In no case must the constitution of these gangs involve undue movement of the personnel from place to place.

To get the best results from the use of mechanical tools supervisors and operators must be well trained in their use and daily maintenance.

10. — The final summaries adopted at the Enlarged Meeting of the Permanent Commission (Lisbon, June 1949) mention the paths for the movement of the men and machines as follows :

« It is desirable in future in the case of new railway construction or when modifying existing lines to provide large cesses to facilitate the use of mechanical equipment and generating plant. »

Besides this, the existence of such paths is also very desirable for the safety of the men, because in a large measure they reduce the movement of men to and from their place of work on the track.

11. — The factors in the evolution of maintenance : concentration of the gangs, organisation of the work and mechanisation, are capable of giving considerable economies compared with the present position; however, each of them has limits to its application.

12. — Concentration enables the management to follow more closely the work of the gangs. It soon loses its advantages, however, owing to the high cost of travelling and lodging when the gang becomes too large and works over such a wide area that the men can no longer return home at night. The social advantages of returning home at night are, however, extremely important.

13. — Mechanisation gives a great increase in individual output, though the saving on the work as a whole is less. The saving decreases very rapidly when the amount of work to be done is small and when the traffic on the lines in question is considerable. It requires very careful predetermination of the work to be done to avoid useless operations.

14. — The general application of the new methods will only be crowned with success when the managerial staff is so trained that it knows the possibilities and limitations of these methods as well as its role in the economies which must result from their application.

QUESTION 2.

A) Modernisation of station buildings and methods employed in financing modernisation projects.

B) Standardisation of unit construction applied to railway building,

by Dr. F. F. C. CURTIS,

Architect, British Transport Commission, British Railways.

Special Reporter.

Question 2 was the subject of two reports :

— Report (America (North and South), Australia (Commonwealth of), Burma, Ceylon, Denmark, Egypt, Finland, India, Indonesia, Irak, Iran, Republic of Ireland, New Zealand, Norway, Pakistan, South Africa, Sweden and the United Kingdom of Great Britain and Northern Ireland and the territories for whose international relations the United Kingdom is responsible), by Dr. F. F. C. CURTIS (See *Bulletin* for November 1953, p. 831).

— Report (Austria, Belgium and Colony, Bulgaria, Czechoslovakia, France and French Union, Germany, Greece, Hungary, Italy, Luxemburg, Netherlands, Portugal and Colonies, Rumania, Spain, Switzerland, Syria, Turkey and Yugoslovia), by José CHEDAS BOGARIM (See *Bulletin* for December 1953, p. 935).

The object of the present report is to sum up the main ideas of these two reports and try to put forward the summaries that can be derived therefrom.

The first part of the question is devoted to an examination of the financial bases of the modernisation of station buildings ; the second to the development and employment of standardised systems of unit construction.

In considering the 60 sets of the answers submitted it has to be remembered that some of the Organisations are privately, others publicly owned and operated; among them are represented several degrees of size and development, and several different economic and financial structures. Yet at the same time a broad similarity in the answers to particular questions argues that railway architectural and engineering problems are similar the world over; it would seem also that younger systems have based their work on the experience of older ones, particularly when managerial or executive staff have gained their experience on other railways.

A. — Modernisation of station buildings and methods employed in financing modernisation projects.

(*Note.* — In the answers to Question « A » the methods of financing the reconstruction of war-damaged stations play a large part. The fact that this has usually been undertaken by the State cannot obviously be taken as representing a normal policy. See answers to A. 6.)

1. — *Are proposals for modernisation of station buildings accompanied by financial and statistical details showing the anticipated traffic and net revenue from the proposals ?*

When station reconstruction (including modernisation in whole or in part) is envisaged, the proposals may or may not be

accompanied by statistics of anticipated traffic and net revenue; there is a distinct difference of opinion on this point. The larger countries of Europe, including most of the busy highly developed railway systems (Britain, France, Spain, Germany, Austria, Switzerland and Greece) submit such statistics while other European, American, African and Eastern Organisations do not.

Perhaps one reason for this is that it may not always be possible to estimate the traffic and revenue; it might be that the psychological effect alone of reconstruction will become a valuable invisible asset. Alternatively, different considerations may carry more weight; for instance, in the case of war damage (which necessitated most of the major reconstructions under review) a station will probably have to be rebuilt, while in developing systems such as those of Africa, India and Indonesia new buildings will be provided because they are required where none already exist, or because temporary structures must be replaced. Again, it is probably that some uneconomic projects must be carried out in the same way that some uneconomic services must be maintained, and modernisation may even be necessary merely to maintain revenue at the existing level (Norway).

However, generally an estimate of costs at least is provided which may be linked with an attempt to forecast future traffic development (Swedish State Railways). Two replies (British Railways Western Region, and the Chicago, Burlington & Quincy Railroad Company of America) speak of submitting details of station earnings over a past period of years, while an interesting point, supplied by the London Midland Region of British Railways, mentions the practice of back-checking selected schemes to establish how far expectations have been realised; similar investigations are no doubt made by other Organisations.

In all cases it is clear that the general policy of the organisation, or the policy as affected by the particular circumstances of the time and place, will constitute the overriding factor.

2. — *Is capital expenditure on modernisation of station buildings related exclusively or mainly to the net revenue from traffic originating and/or terminating at such station?*

The capital expenditure involved in such modernisation is not, with very few exceptions, related exclusively to traffic originating and terminating at the particular station. Apart from the question of exchange or transit traffic, other factors considered are the age and condition of the buildings, the existing maintenance liabilities, and possible economies in staff or structure where either the traffic pattern has altered or improved methods of working are available.

Where the anticipated net revenue from reconstruction is assessed, the annual maintenance and renewal liabilities may be calculated on a uniform or a differential basis, depending upon the Organisation's building programme and its financial structure; no clear trend emerges here.

6. — *How is provision made for the long-term capital expenditure involved in the reconstruction in stages, and over many years of very large stations?*

Very large reconstruction projects are always carried out in stages, each financed separately and the long-term capital expenditure involved may be provided for in several ways, largely depending upon whether a railway system is publicly or privately owned, although reconstruction necessitated by war damage is generally paid for by the State. State-owned systems are mostly obliged to work to a budget voted them by Parliament, hence long-term planning of major works will be a necessity. Loan capital is employed by a few systems (France, East Africa, Ceylon) but it would probably be true to say that expenditure is met, wherever possible, from revenue, working capital, or renewal and depreciation reserves (in France only 20 % of the cost is charged to operating costs, the balance being met by State or private loans).

3. — *Is it the practice to take into consideration earnings in the form of rents and/or percentages of profits from ancillary services, such as :—*

Shops and kiosks;

Restaurants and hotels;

Cloakrooms and hairdressing establishments;

Day hostels;

Show cases and commercial advertising?

Direct contributions to the capital cost of modernisation are seldom sought (Germany, Holland) in respect of ancillary services such as shops, restaurants, hotels and advertising display, unless work is carried out solely for the tenants. Tenants pay rent or a percentage of their profits, which may be raised when the amenities are improved or lowered if the tenant has made a capital contribution to the reconstruction; at the same time it may be difficult to adjust these payments unless existing agreements can be cancelled. Most Organisations appear to take into account the earnings from ancillary services, but, except at large terminal stations, the amounts involved are obviously not of very great importance. In fact the general attitude on this question seems unadventurous. Presumably tenants take up these concessions because they are profitable; were it not for the station they would not exist, and it might be assumed that well-designed new buildings are at least as likely to attract more traffic and consequently more trade as not.

8. — *To what extent and on what basis have outside bodies, such as local authorities, contributed towards the cost of reconstruction projects?*

Similarly, contributions to reconstruction by local authorities are limited in extent except where work is carried out directly for their benefit (this usually involves only road or bridge works, the cost of which is shared proportionately with the railway), although rent may be paid for special accommodation. Again war damage is a particular problem which may attract such capital contributions as loans (France), and in one case it is interesting to note that capital, materials, or labour may be supplied (Spain).

The habit of regarding a railway station as a civic building as much as the town hall or public library is not common, although in many cases it is the first (or only) town building the traveller sees and uses; one would expect that local pride allied to commercial instinct would see here a great opportunity.

7. — *What formulae are used in the allocation of expenditure on modernisation between capital and revenue accounts?*

In minor works, replacement, maintenance and repair, are generally charged to revenue, improvements to capital account (in France modernisation costs up to 5 million francs are allowed on the operating account). In America the accounting procedures and regulations of the Inter-state Commerce Commission are taken as a guide. In India a net return of 4.25 % is required on new work debited to capital, so that unremunerative work, involving mostly passenger amenities, is charged to a development fund created out of revenue.

5. — *What steps are taken, in the planning stage of a reconstruction project, to ensure that administrative economies arising from improved methods of working, mechanisation, etc. are considered with a view to achieving economies in building*

In the planning stage of all reconstruction schemes it is the general practice to try to make economies by taking advantage of the most up-to-date equipment and methods of working. Lavatory, waiting room and office facilities may be grouped or amalgamated, and staff reduced with resulting economies in the size of the building (and, therefore, in materials, services and

maintenance costs). However, although the point has not been raised it is conceivable that the reverse may apply; that increased efficiency may allow the handling of more traffic, which will in return require larger buildings. Be that as it may, this process is, of course, a continuous one, and is achieved by constant consultation between all departments concerned; thus in the planning stage several successive preliminary schemes may have to be examined and rejected.

B. — Standardisation of unit construction applied to railway building.

1. — *What system of standardised unit construction has been adopted, if any?*

   a) *Is the system based on a module or planning grid?*

   b) *Have good results been achieved in the provision of thermal insulation; insulation against damp; sound insulation?*

   c) *Has the system been so developed that the erection of buildings can be undertaken by the railway's own labour?*

   d) *Has there been a problem of storage of component parts, their transport to building sites, and the supply of spares*

3. — *Has unit construction been applied to a variety of types of buildings or was it only used for one type, such as simple platform buildings, sheds, etc.?*

The development of standardised unit construction depends to some extent on the character of a particular railway system, since wide variations in climatic and geographical conditions may be encountered. For railway purposes it appears to be not so much the answer to a long-term programme of buildings which can be accurately forecast as to a need for temporary structures which can be quickly built, quickly removed, and easily enlarged or adapted.

Almost every railway makes use of standard units or standard construction in some way; complete constructional systems are based mainly on combinations of post and panel walls with beam and slab roofs. The types of structure for which such work is used vary from platforms, fencing, kiosks and linemen's huts to houses, service buildings, locomotive and goods sheds.

With certain exceptions (mentioned in more detail further on) modular or grid planning does not appear to be used, except insofar as the particular building components used dictate a dimensional pattern; the standard plan is more general. Nor does any special attention appear to have been given to insulation problems, since the buildings involved probably need no particular level of insulation; but at the same time a unit system usually includes a double skin or « sandwich » cladding, and the question has obviously been considered in the development of these structures, since satisfactory results are reported. In erection, railway labour is generally used for small projects only, and because these unit constructions form an unimportant proportion of the total building programme there is no reported problem of storage or transport of components; in many cases these are produced as required.

Perhaps the most significant answers are those which show countries using standard components (France, Spain, Switzerland); these may be developed in collaboration with the building trade and building research institutes (Norway, Sweden, Denmark). The logical answer to railway problems lies perhaps in the development of standard equipment and furniture rather than of standard buildings, a trend which runs parallel to current thoughts on prefabrication in general. This permits economy, speed and flexibility in building without the disadvantages of possible shortage of materials or radical changes in technique.

To deal in more detail with complete

systems of unit construction, several different modules are mentioned : 4″, 60 cm, 36″, 39″, 40″, together with bays of 8′ 6″, 10′ 0″, and 12′ 0″. Four inches is a favourite American module applicable to brick and timber standard construction, and 40″ a favourite English one, recommended by the British Standards Institute as conforming to the metre and having decimal properties, while giving door, corridor and staircase widths (1 unit), door heights (2 units) and 10′ 0″ bays (3 units). But it does not appear common practice to use these modules in more than one dimension; usually they make up the length of a building rather than the width.

With the possible exception of the French Railways, most work in this field appears to have been done by British Railways both before and after nationalisation in 1947; but this has not all been co-ordinated nor carried to a conclusion. The L.N.E.R. established standards for :—

Station signs;
Notice and poster boards;
Barriers and gates;
Sanitary fittings;
Heating, lighting, ventilation;
Booking offices.

The L.M.S. studied principles of station planning and related accommodation to volume of traffic including :—

Number and sizes of entrance doors;
Sizes of concourse;
Number of ticket windows and barriers;
Number of lavatories;
Widths of subways and staircases.

The G.W.R. studied :—

Capacity of approach roads;
Time and space requirements for alighting passengers;
Booking office statistics;
Time and space requirements for platforms and concourses;
Speed and volume of pedestrian traffic in circulation.

In standard unit construction the G.W.R. experimented with seats, window surrounds, built-in furniture, roof panels and aluminium panels for country and suburban platform buildings.

The L.M.S. developed a system based on a module of 40″ using steel columns with pre-cast concrete or enamelled steel panels giving a minimum wall thickness of 2 1/2″ and a U. value of 0.25. Two prototypes were built but full-scale production was never started.

Currently the Eastern Region of British Railways have developed a system, again based on a 40″ module, using pre-cast concrete columns and eaves beams with standard metal windows and several types of cavity or sandwich panel infillings; roofs are of foamed slag slabs laid between pre-cast beams with an in-situ topping. This system is intended for a large programme of welfare buildings and allows flexible planning.

4. — *Has the development of standardised unit construction been related to that of a standard practice in station working, and have there been advantages in this?*

As previously indicated unit construction has nowhere been very closely bound to any particular type of railway building (excepting on the L.M.S. and Eastern Region of British Railways), rather it has been considered as a flexible and economic auxiliary to normal building methods. Therefore it is not strictly related to the development of standard practice in station working, except insofar as standard equipment or components are involved (particularly for booking offices). The two are likely to proceed at different rates of development and any too close a link might prove to be uneconomical. A general tendency is to standardise equipment for stations of similar size, but obviously a station too carefully « tailor made » might soon prove uneconomic.

5. — *Has such a development been linked with a policy to aim at uniformity of appearance and colour treatment in stations?*

In this connection uniformity of appearance and colour treatment is not generally sought or desired, although standard colours are used by several systems (British Railways, Denmark, various American Companies); local conditions and environment are usually the first consideration.

11. — *To what extent has it been found suitable to use standardised unit construction for small-scale improvements at existing stations?*

In small scale improvements at existing stations much will depend on the units available. Obviously part or whole of a building reconstructed in a post and panel system may not blend with older buildings or their surroundings unless facings of a suitable character are available, although the complete reconstruction of a suburban station may be permissible. On the other hand, standard components, furniture and fittings may easily be introduced; booking office windows, poster panels, seats, lights, and fencing would be examples of these.

2. — *Has it been found that standardised unit construction has advantages over other forms of construction in regard to :—*

a) *economy of first cost;*
b) *economy of maintenance cost;*
c) *economy in the use of materials;*
d) *speed of erection?*

It is the general opinion, however, that unit construction when used in appropriate cases is both cheaper in first costs and quicker to build than conventional structures. In material and maintenance costs it is not necessarily cheaper, nor is its useful life as long, although on the latter points experience is lacking. Materials used are generally normal building materials, even if prefabricated in unusual ways. With complicated systems comparatively large building programmes and a constant supply of materials might be needed to keep costs down, but the ability to salvage and re-use components also makes for economy.

10. — *Have scarities of raw materials been a check on the application of standardised unit construction?*

The shortage of raw materials — chiefly the world-wide shortage of steel and cement — has affected the application of unit construction in some countries. In certain cases unit systems have been expressly designed to exclude key materials, in others it has been possible to use substitutes. But shortages are just as likely to affect normal building operations, and any material might become scarce at some time because of national or international circumstances.

9. — *Have fluctuations in the cost of materials or labour had an adverse effect on the application of standardised unit construction?*

The same arguments hold good when considering the effect of fluctuating costs of materials and labour. It is generally agreed that these have no adverse effects on the application of unit construction. Fluctuations in the cost of building labour may encourage the use of such systems, while fluctuations in the cost of materials or factory labour will affect other forms of building no less. Traditional and unit construction may be held to be complementary to each other, and any particular circumstances affecting the employment of either will be weighed at the planning stage of each project.

7. — *Has it been found that technical developments in the building industry tend to render any system of standardised unit construction out of date, or was it possible to make adjustments without difficulty?*

Technical developments in the building industry might be thought to affect unit construction, but it appears that adjustments can be made if required. The pace of building development is relatively slow because of the need for testing and assimilating new products, and it is unlikely to outstrip the progress of prefabricated systems which, consisting of simple elements such as column, beam and slab, should be easily adjustable to new materials.

8. — *Has it been found that standardisation of unit construction is a disadvantage because individual initiative to develop new methods of construction is given too little scope?*

Since standardisation of unit construction has a limited scope, being generally applicable only to small one-storey buildings which do not in any case present great structural problems, it does not, with few exceptions, destroy initiative in developing new forms of construction. Anything but the simplest one or two-cell building must still be planned and the elements of the system adapted to it. But standards must be constantly reviewed so that advantage is taken of new developments; the drawing office time saved by the application of standards can be used for this purpose.

6. — *Has any method been developed of prefabricating and factory-assembling small buildings which can be transported complete and placed on prepared sites?*

As an additional development of unit construction several railways have made use of small huts and kiosks, pre-assembled and transported to prepared sites (also small houses — Finland). Factors affecting these are the loading gauge, the size of crane needed to lift the building and the availability of the track for the necessary time. Unless either a very large number of them are required at one time or many temporary buildings are needed which can be moved to other sites at short notice, it would not seem that there is much scope for development in this field, especially in fully developed railway systems where new works in remote places are not required.

* * *

SUMMARIES.

PART « A ».

Modernisation of station buildings and methods employed in financing modernisation projects.

1. — A number of administrations operating important railway systems base their modernisation projects on statistics of the anticipated volume of traffic and revenue therefrom. Others, mainly smaller ones, regard the traffic requirements alone as sufficient justification.

2. — In minor works, replacement, maintenance and repairs are generally charged to revenue, improvements to capital account.

3. — Very large projects are always carried out in stages, each financed separately. Wherever possible, expenditure is met from revenue, working capital or renewal and depreciation reserves, though some administrations employ loan capital.

4. — The annual maintenance and renewal liabilities are in some cases calculated on a uniform basis for all types of construction, but some administrations differentiate between buildings with a long expectation of life and those of a more temporary construction.

5. — Most administrations take into account the earnings from ancillary services, but, except at large stations, the amounts involved are not of great importance. Nevertheless, there is much to be said for exploiting to the fullest extent the possibilities of earnings from shops, restaurants, hotels, advertising display, etc. A considerable portion of the money needed for station reconstruction can, in favourable circumstances, come out of revenue from ancillary services, or from capital contributions made by tenants.

6. — Contributions towards station reconstruction projects from local authorities are limited in extent, except where work is carried out directly for their benefit. Only rarely has local pride, allied to commercial instinct, seized the opportunities offered in making a railway station a civic building.

7. — In the planning stages of reconstruction schemes the general practice is to try to make economies by taking advantage of the most up-to-date equipment and methods of working. It is most important that the designers and the using departments work in the closest co-operation in order to obtain the fullest benefits from saving in personnel and improved working.

PART « B ».

Standardisation of unit construction applied to railway building.

1. — For railway purposes, standardised unit construction appears to be the answer to a need for temporary structures which can be quickly built, quickly removed and easily enlarged or adapted. Its use has, on the whole, been limited to buildings of an industrial character, such as locomotive sheds, goods depots and to various types of small buildings such as lengthmen's huts, shelters and small stores.

2. — For station buildings generally and for non-industrial buildings the character of the countryside, climatic conditions and local customs are taken into account. Such buildings must not become discordant factors in their surroundings and nearly always need to be specially designed.

3. — It appears to be the general view that, at least as far as initial cost and rapidity of construction are concerned, standardised unit construction systems have advantages, but the greatest advantage from standardisation in buildings has been gained from the use of standard components especially those in general use in the building trade, standard fittings and equipment.

4. — It is unlikely that technical developments in the building industry will outstrip the progress of prefabrication systems.

5. — The application of standardised unit construction does not need to destroy initiative among technical staffs since standards must be constantly under review.

SECTION II. — Locomotives and rolling stock.

[621 .33]

QUESTION 3.

Technical and economic investigation of the basic characteristics of electric traction systems now in use, with a view to decide whether, and to what extent, there are relevant reasons for preferring one system to another.

In particular, are there any reasons in regard to :

a) power supply;
b) overhead line and fixed track installations;
c) motive power units;
d) working and maintenance costs,

by S. B. WARDER,

Chief Officer (Electrical Engineering), British Transport Commission, British Railways,

Special Reporter.

The question was dealt with in two reports :

— Report (America (North and South), Australia (Commonwealth of), Burma, Ceylon, Denmark, Egypt, Finland, India, Indonesia, Irak, Iran, Republic of Ireland, New Zealand, Norway, Pakistan, South Africa, Sweden and the United Kingdom of Great Britain and Northern Ireland and the territories for whose international relations the United Kingdom is responsible), by S. B. WARDER (See *Bulletin* for October 1953, p. 657).

— Report (Austria, Belgium and Colony, Bulgaria, Czechoslovakia, France and French Union, Germany, Greece, Hungary, Italy, Luxemburg, Netherlands, Poland, Portugal and Colonies, Rumania, Spain, Switzerland, Syria, Turkey, and Yugoslavia), by C. GUZZANTI (See *Bulletin* for March 1954, p. 297).

General.

The questionnaire upon which the two Reports by Messrs WARDER and GUZZANTI were compiled were sent to 50 countries where were located 103 Railway Administrations. Of these Administrations relatively complete replies to the questionnaire were received from 23 (9 from English speaking and 14 from French speaking countries).

Replies would not, of course, be expected from Railway Administrations which had no electrification system or only operated electrified services of such a nature that information on them would be of little or no value for the purposes of this enquiry. Certain Administrations specifically limited their replies to specially selected lines which could supply representative data upon which reasonably accurate conclusions could be formed.

The Reporters are, therefore, particularly grateful for the objective manner in which this question has been approached for it was an extremely formidable under-

taking firstly to supply the required information, and subsequently to interpret all the replies into one common answer. These reports are largely based on information relating to main line as distinct from suburban railways.

It is significant that the investigation is made at the completion of about 50 years experience of electric traction, and the Reporters draw attention to the changes that have occurred since Electric Traction was last the subject of an economic investigation by the I.R.C.A., viz: in Cairo 20 years ago. On that occasion comparisons were for or against electrification, whereas to-day's question is between different systems of electrification though both reporters naturally mention that the former question is still of interest in view of the advent of the Diesel engine as a widely used agent for motive power.

In this intervening 25 years, new techniques have been developed for the already established D.C. systems at 1 500 and 3 000 V and the single phase low frequency A.C. system at about 11/16 kV, and with the last few years the high promise of the standard frequency single phase system at 25 kV makes the present investigation so interesting and so timely.

It is of great interest to Railway Electrical Engineers to review the changes in technique over the years as they develop in different countries but the main object of the question is presumably to allay any apprehensions among those responsible for approving railway policy as to the correctness of their motive power for their particular purposes. This has led one of the Reporters into a short dissertation on the interpretation of the question, from which it would seem that what is best for one country is not necessarily the best for all or any other one country. In this connection an important factor is the high investment in many countries in systems giving excellent service with the result that neither reporter mentions any country as likely to abandon its existing system in favour of a new one.

Power supply.

In the early days of electric traction there have been many instances where the provision of a power supply system primarily for railway use has facilitated the development of electricity for public use. In this respect the direct current system had some advantage over the low frequency A.C. system which required special high voltage distribution lines. However, the problems of power supply have, in general, now moved from the railway to the Public Supply Authority. The reason is mainly because of the growth of the industrial load and the consequent development of national interconnecting power line systems at a standard frequency of 50 cycles except in the U.S.A. where 60 cycles is usual. It will be appreciated that those systems, which supply loads far in excess of that required by the railway, also lend themselves admirably to the use of the single phase standard frequency system.

The Power Supply Authorities are interested in the size of the railway load, its characteristics relative to power factor, wave shape and load curve, whereas the railways are mainly concerned with price and reliability. That these mutual questions are generally resolved without undue difficulty may be regarded as a confirmation of the attractiveness of the railway load to Public Supply Authorities.

A matter which is of supreme importance to Railway Administrations is the cost of electric current. The answers to the questionnaire disclose wide disparity between the various tariffs charged by Power Supply Authorities and it is suggested that here lies further scope for enquiry. It is considered that the importance of the railway load should be recognised by an appropriate tariff which takes proper account of the nature of the load and which in the aggregate should often be lower than that charged for industrial loads of similar magnitude.

Both reporters agree that none of the available systems of electric traction

demands special characteristics on the power supply system.

Substation spacing.

When considering the question of power supply it is impossible to avoid taking into account the question of Substation Spacing whatever the type of system and in this connection a high proportion of substations on any railway site themselves at important junctions for strategic and operational considerations.

For D.C. systems the mean distance apart is of the following order :

1 500 V : 10 miles, varying 5 to 15;
3 000 V : 20 miles, varying 10 to 35.

For the alternating current systems with their higher voltages, longer distances are permissible although the higher impedance of the 50-cycle systems and the variety of locomotives, some more capable than others of compensating for wattless current, makes generalisation very difficult. However, the information received indicates that the average substation spacing for the 15 000 V single phase low frequency systems is not much more than double that for 3 000 V D.C. systems. By raising the voltage to 25 000 V a spacing of this order can be maintained with 50 cycles.

It is, however, clear from the replies that the distance between substations varies almost as much from one railway to another as from one system of electrification to another.

Unbalance of single phase load.

One of the problems still exercising electric traction engineers which is associated with standard frequency single phase electrification is the undesirable unbalancing effect on the three phase high voltage supply line.

There is insufficient experience available on a large enough scale to indicate the limits between which unbalance can be sustained but it is evident that this must be largely related to the proportion of the railway load to that of the power supply system at the point of delivery and to the characteristics of the system. No particular difficulties in this respect have so far been reported and it may well be that the problem often resolves itself partly because densely trafficked systems are most likely to be associated with districts where a correspondingly large public supply exists. Likewise, in sparsely populated districts the demand for railway power would be correspondingly reduced. This may be an optimistic point of view for which only limited evidence exists but the difficulty still remains that the arrangements for supplying power to the tracks cannot be made exclusively for railway convenience but must also have regard to reducing unbalance to a minimum regardless of the frequency of train movements and layout of running lines.

Overhead line and fixed track installations.

Overhead contact line.

There are considerable differences of opinion on questions such as the best way of securing minimum wear with sparkless collection. It would seem that there is still much scope for improvement in pantograph and overhead line design and further development of self lubricating high conductivity collection strips with a view to a reduction in operating and maintenance cost.

Those systems requiring the smaller currents which is usually secured by an increase of voltage, naturally have the advantage from the point of view of current collection.

For all systems the universal practice is for the contact line to be suspended flexibly from one or two catenary wires. Variations occur according to circumstances of track layout, but few catenary and contact wires are rigidly anchored, automatic regulation of tension in contact wire and/or catenary by counterweights being more often provided.

Bronze catenary wires are mostly preferred to copper and the use of steel is very rare. Contact wires are generally of copper but cadmium copper is also becoming widely used.

The amount of copper required has a considerable bearing on the strength of the supporting structures and this is where the higher voltage systems have the advantage. Other factors, however, tend to lessen this advantage, such as the allowance to be made to resist wind and ice and to negotiate curves.

These factors play a large part in determining the spacing of structures and the reports show that the structure spacing is usually much the same for the high voltage A.C. system as for the lower voltage D.C. lines.

The greatest possibility of economy in overhead support costs, namely by the reduction in the number of structures and points of insulation is thus lost.

The wide range of structure types required for the variety of conditions which arise for different systems and country make it difficult to refer to them all while keeping this summary to a reasonable length. Many interesting facts have, however, been collected together in the two Reports which are well worth study by those especially interested in this subject.

Two aspects are, however, worthy of special mention. One is the possibility of economy by the use of pre-stressed concrete, particularly for vertical poles on single line tracks. The other is the design of foundations for installation at the minimum cost and with special regard to the nature of the soil where they have to be located.

Minimum clearance between live and earthed apparatus.

There are large diversities between the values quoted for the minimum permissible clearances between contact wire and loading gauge and between the contact system and earth. This may be due to a variety of causes — presence or absence of steam traffic on the lines in question, general atmospheric conditions, ease or difficulty of obtaining clearances and possibly also to failure to distinguish between normal and absolute minimum values.

Values are reported over the following range for the sum of the two clearances mentioned :

1 500 V, D.C.	200- 350 mm
3 000 V, D.C.	300- 500 mm
L. Freq. A.C.	400- 900 mm
50 cycles A.C.	520-1 500 mm

The two reporters reach different conclusions on the economic importance of this matter — one concluding that the problem of clearances should not cause substantial differences between the various systems of electric traction — the other that particularly where steam traffic is anticipated over electrified lines on which it is difficult to get clearance for any system, the cost of obtaining the higher clearances needed for the H.V. system may have important consequences financially.

This matter would seem to warrant further and detailed investigation.

Inductive and electrolytic effects.

Modern telecommunication and signalling practice is for all circuits to be cabled and this has been done in almost every case where railways have been electrified on the overhead system. Some railways using overhead D.C. systems supplied from mercury arc rectifier substations incorporate apparatus for suppression of those harmonics liable to cause interference to paralleling telephone circuits; others have not done so and do not propose to do so. The reason for cabling circuits and installing filters as well is not clear.

A.C. systems have an advantage over D.C. systems by giving immunity from electrolytic troubles caused by leaking currents. The problem is well understood but

sometimes difficult to combat, although most Administrations report only minor difficulties from this cause.

Substations.

Continental practice is generally to make use of open type switchgear arranged either for indoor or outdoor mounting. In England the unit type of ironclad high voltage switchgear for indoor mounting is mostly preferred on grounds of safety and space saving. For D.C. systems the rotary convertor is now outmoded and is being rapidly superseded by the mercury arc rectifier.

On the Continent, the pumped water or air cooled rectifier is practically universally used, whereas in England and in many overseas British Dominions the pumpless type of rectifier is preferred. This is essentially an English invention, and so far the performance of these units has been entirely satisfactory. Similarly, the use of glass bulb rectifiers has proved to be very successful. Such rectifiers already have gained a much higher record for reliability than their pumped counterpart.

In suitable conditions electric traction offers considerable benefit from the possibility of regeneration for either economy of power or for braking purposes.

For alternating current low frequency systems the use of rotating frequency changer plant already well established seems likely to continue. For 50-cycle alternating current systems, the main attraction of which is the lower cost of fixed installations, it seems likely that supplies from main power lines will be taken through isolating transformers with 2 phase/3 phase connections in order to reduce out of balance to the minimum.

The question of whether substations are to be manned or operated by remote supervisory control usually depends on the system of electrification and local circumstances.

Motive power units.

The Reporters have made it apparent that their task has not been an easy one for each system can show many good reasons for being preferred in the particular circumstances for which it has been selected.

It has proved almost impossible to compare the real characteristics of locomotives for one system with those for another simply by comparison of the quantities included in the schedules.

Both Reporters, however, note that recent locomotives are almost all of the total adhesion type, generally with bogie mounted motors, thus making the best use of the weight of the locomotive for traction but bringing with it problems in bogie design arising from high axle loads and the use of driving wheels for guiding the train.

The reports note differences of practice in the rating of locomotives, e.g. in nominal coefficient of adhesion, use of 1 hour or continuous motor ratings, speed at which rated horsepower is stated.

The locomotives under review, irrespective of system, comprise those for three classes of duties, viz: freight, passenger and mixed traffic. Freight locomotives generally require large tractive efforts at not very high speeds; passenger locomotives a lower tractive effort at higher speeds, mixed duty locomotives necessarily partake of both characteristics. In these circumstances, quantities such as H.P./ton weight of locomotive, which vary widely as shown in the reports and schedules, do not adequately reflect these differences in the work to be done and are therefore inadequate as a criterion of locomotive worth.

All the well established systems have permitted the construction of excellent locomotives and within the ambit of this report it would be invidious and dangerous to attempt to distinguish any marked predominance in performance of one type over another. Satisfactory arrangements

are made to allow the D.C. series motor to give the excellent performance of which it is capable on all three classes of duty — a different technique, generally involving fewer larger motors, gives the series commutator motor of the low frequency systems the chance to operate in the range for which it is most suitable.

The coming of the 50-cycle single phase system has brought both new problems and a valuable reassessment of the optimum arrangement for the electric drive of locomotives. Full experience of the various combinations of power conversion to be used on the S.N.C.F.'s Thionville-Valenciennes line will therefore be studied with exceptional interest and any conclusions made in advance of this must be highly provisional.

The well known difficulty of obtaining reasonably good commutation with 50-cycle commutator motors over the range of speed and current that are needed seems still only to have been partly solved and the S.N.C.F. locomotives under construction are mainly of types in which the current is converted on the locomotives either to D.C., to rectified A.C. or to 3 phase A.C. Each locomotive thus becomes in effect a mobile substation with the attendant advantages and disadvantages thereof. The conversion may be made by rectifiers, by motor generators or by motor converters, and the S.N.C.F. are trying out each method. Each method has advantages and disadvantages which are examined at some length in one of the reports. All seem to tend to increase the weight and complexity of the locomotive for a given duty by comparison with its conventional D.C. counterpart. Most bring advantages in continuous methods of control, making the locomotive performance largely independent of the voltage drop in the contact line. Some of these methods hold promise of reducing liability to slipping of wheels and of improved performance with wheels of differing diameters.

All of them would appear likely to increase the cost of such a locomotive by comparison with its standard D.C. counterpart, if all were manufactured under exactly corresponding circumstances for equal performance, but the price schedules do not disclose this as being the case.

The A.C./D.C. combination locomotive has a further facility to offer, namely that of interrunning with existing D.C. systems. Such a possibility thus permits the introduction of the single phase standard frequency system into countries already using the D.C. system to the economic limit, and where circumstances do not permit its extension.

Electric motor coaches.

One of the most fundamental features of electric traction is that the prime mover is removed from the train and from the earliest days this conception has permitted considerable latitude in the means by which the vehicles could be propelled. In its simplest form the coaches were arranged to accommodate the traction equipment and no suburban electric railway system would to-day contemplate anything using other than what is now conveniently described as multiple unit sets. So far this type of stock has been seldom used for main line passenger work, possibly because freight traffic predominated, or because in the interest of economy it was expedient to replace the steam motive power by electric locomotives.

From the characteristics which the Reporters have supplied of the various types of electric locomotives it will be evident that there is a strong tendency towards total adhesion and bogie mounted motors. Thus one of the most important problems for designers is the improvement of riding at high speeds, for with the exception of the British Railways Co-Co locomotive none of the modern locomotives are permitted to run at over 70 m.p.h. Notwithstanding this, there is no hesitation in running multiple unit stock at speeds up to 90 m.p.h. and even higher.

It would seem that there is scope for the expansion of high speed multiple unit train services to a much greater degree than exists at present.

Economic investigation.

Both the Reporters have had considerable difficulty in making an effective comparison of initial and working and maintenance costs. In spite of the detailed information given by some Railway Administrations, such comparisons as have been possible show a greater variation from country to country than from one system to another.

Although an attempt was made to eliminate some of the potential difficulties by asking that costs be brought up to the level ruling at a given date, such corrections must inevitably be imperfect. In no country, except France, is it possible to make any comparison between the first and running costs of different systems of electrification, and even in France the comparison is between parts of the railway differing in character, and in the case of the new 50-cycle system the running costs can at present necessarily only be estimated. Effective comparison of maintenance and running costs on railways differing so widely in their characteristics and in the system and date of electrification, seem only to be possible after minute examination of accountancy methods and debatable adjustment for difference between the size of maintenance units and methods and for variations in electricity tariffs if the comparison is to be a realistic one of the economic advantage of one system over another.

One of the Reporters has attempted some comparisons, but for the reasons given they cannot be conclusive, but attention is drawn to differences in the method of calculating interest and provision for renewal which vary considerably from one country to another. It may well be that the relatively short life of electric traction has not been long enough to produce proper assessment of the true life of the different components. There are, for instance, many items of the fixed equipment which have an unlimited life, whilst others can be preserved indefinitely provided adequate maintenance and attention is given. On the other hand, it is not improbable that new technical developments would make it convenient to replace other equipment, in particular perhaps rolling stock, before the end of the life which could be obtained with normal maintenance. The statistical lives used in different countries for the ascertainment of renewal provision vary, for example, as follows :

Substations	30-50 years
Overhead contact system.	40-60 years
Motive power units . .	33-45 years

In these circumstances, both reporters have made brief estimates of the financial effect of electrifying sample lines on 1 500 V D.C. and 25 kV single phase 50 cycles A.C. systems, and subject to all the qualifications implicit in an estimate of this kind, both Reporters reach the conclusion that the latter system is of great importance for lines of relatively low traffic density which yet warrant electrification, but that on most lines the choice between systems can only be made on economic grounds by detailed comparative estimates, taking all the special factors of the lines concerned into account.

SUMMARIES.

General.

1. — The investigations of the Reporters show that for all practical purposes the only systems suitable for extensive railway application are :

Direct Current . . .	1 500 V;
Direct Current . . .	3 000 V;
Alternating Current .	low frequency at 11/16 kV;
Alternating Current .	standard frequency at about 25 kV.

2. — Each of these systems has features in the technical, operational, and economical fields which make one or other of them particularly suitable in certain circumstances.

3. — They, however, each possess certain less advantageous features which have to be taken into account when a choice of system has to be made.

Power supply.

4. — The power supply system does not normally determine the choice of electrification system as all can be arranged for supply from systems feeding other loads.

5. — However, this enquiry has shown that there is a wide disparity of tariffs and further study of these and of the possibility of special rates being given to the railways is recommended.

Fixed installations.

a) **Substations.**

6. — D.C. systems require a greater number and sometimes more complicated substations than are required for A.C. systems.

7. — Of the two A.C. systems the standard frequency system permits the simpler substation, because frequency converters are not required.

8. — Until more evidence is available, it must be feared that this simplicity is accompanied by the inconvenience due to the reaction of unbalancing effects on the power supply and certain restrictions on the possibility of affording parallel supplies to sections of the railway.

b) **Overhead contact lines.**

9. — The A.C. systems permit the use of smaller cross sections in the contact system than are needed for the D.C. systems; after allowance has been made for the difference in line voltage, the substation spacing, the average and maximum values of drop of voltage are of the same order for A.C. systems.

10. — The lower weight of the contact line permits a reduction in the strength of the supporting structures and their foundations, but on account of restrictions imposed by wind forces and track curvature, the spacing between structures is of the same order for all systems.

11. — There are wide diversities in the amount of clearance reported necessary on the various systems in different countries, probably due to the climate, amount of steam traffic and perhaps to a different method of defining the clearances. A standard method of defining the clearances should be used.

12. — The advantages of the light weight overhead systems are most pronounced on railways of simple formation in open country and are of less importance in built-up areas with multiple tracks, many junctions and difficulty in obtaining necessary clearances.

13. — Satisfactory overhead contact systems can be built for all the systems.

Motive power units.

14. — There is a marked trend towards the total adhesion type of locomotive, usually with bogie mounted motors, for all systems.

15. — Differences in the method of rating and the type of service preclude the possibility of exact comparison between the characteristics of locomotives working on one system of electrification with those of another.

16. — Satisfactory locomotives for freight, passenger and mixed traffic have been built for all systems and there has been a steady improvement in the quality of performance of locomotives of all types.

17. — Locomotives of each system have certain characteristic advantages and disadvantages.

18. — The advent of the 50-cycle system has led to a re-evaluation of the characteristics required of an electric locomotive and has resulted in several new and interesting types being built by the S.N.C.F. for the Thionville-Valenciennes line. These types have great promise of overcoming the traditional difficulty of bad commutation with normal frequency A.C. series motors. Some of these types seem to avoid the additional weight and expense formerly thought to be essential to overcome the difficulties.

Final judgment should, however, be deferred until sufficient operating experience has been obtained.

Locomotives converting A.C. to D.C. hold out prospects of simplifying interrunning between railways electrified on different systems.

19. — The multiple unit type of electric train is an important feature of most electrification schemes which cater for passenger traffic, and it is considered that there is still further scope for its exploitation.

Economic investigation.

20. — The widely differing conditions which exist between countries make it impossible to place any great reliance on a direct comparison of the costs of their respective systems.

21. — As regards the comparison of first costs between different systems, the variation is not only very great as between different countries but is affected to a certain extent by the diversity in size and type of the respective systems.

22. — The information received regarding maintenance and operating costs has not permitted a conclusion about the effect of the system in use on these costs. This is probably because the size, type and age of the installations, particularly of the tractive units, which affect the maintenance cost very considerably, are so variable as to prevent an effective comparison being made.

23. — A great reduction in the first cost of the fixed equipment such as is often possible under favourable conditions for the standard frequency single phase A.C. system will favourably affect the possibility of electrifying lines which would not justify electrification on the other systems. This is a big factor in favour of the system, but a more accurate assessment of this advantage could be made if a common formula were devised for determining more realistic fixed charges for different items of equipment.

24. — How far this system could supersede other systems for the electrification of lines in which the cost of fixed installations is of less importance because of the greater number of the tractive units required, is still uncertain.

25. — There seems to be insufficient information at present to confirm any definite superiority of any of the four main systems in all respects which would permit any one to be preferred over the others under conditions at present obtaining.

26. — The evidence at present available suggests that it is unlikely that in the forseeable future one system will prove to be the best for all railways having regard to their very diverse characteristics.

27. — In any case, such superiority, wherever it exists, is unlikely to be sufficient to justify the cost of replacing an existing system of the other three types considered with the one having only a marginal advantage.

28. — On most lines the choice between systems can only be made by detailed comparative estimates, taking all the special factors of the lines concerned into account.

[621 .131 .2]

QUESTION 4.

Means and methods to improve the efficiency of steam locomotives :

a) increase of steam pressure,
b) types of grates,
c) superheating of the steam,
d) preheating of the feeding water,
e) feed water treatment,
etc.,

by R. SQUILBIN,

Ingénieur principal à la Société Nationale des Chemins de fer belges.

Special Reporter.

Question 4 has been covered by the two following reports :

Report (Austria, Belgium and Colony, Bulgaria, Czechoslovakia, France and French Union, Germany, Greece, Hungary, Italy, Luxemburg, Netherlands, Poland, Portugal and Colonies, Rumania, Spain, Switzerland, Syria, Turkey and Yugoslavia), by M. DIEGOLI. (See *Bulletin* for April 1954, p. 435).

Report (America (North and South), Australia (Commonwealth of), Burma, Ceylon, Denmark, Egypt, Finland, India, Indonesia, Irak, Iran, Republic of Ireland, New Zealand, Norway, Pakistan, South Africa, Sweden and the United Kingdom of Great Britain and Northern Ireland and the territories for whose international relations the United Kingdom is responsible), by C. T. LONG. (See *Bulletin* for January 1954, p. 117.)

These reports show very clearly the great change which has come about in the technique of motive units since the Paris Congress, in 1937, when the same problems were dealt with (Question V) : in 1937, the steam locomotive was in a preponderant position compared with other methods of traction and endeavours were being made to consolidate its pre-eminence by the introduction of various improvements, going so far as to abandon the standard type of construction with a view to increasing considerably its efficiency, power and speed; the rapid rise of its rivals, electric and diesel traction, and the events of the 1940-1950 decade, which were not favourable for the development of machines as specialised as steam locomotives, have contributed to its decline, so much so that today the steam locomotive can no longer compete directly with the electric and Diesel locomotive in the direction of new construction.

This position of things entails in the development of the steam locomotive a radical change in policy : the Administrations which do not envisage the construction of new steam locomotives but still have very many locomotives which will have to remain in service for many years to come are now seeking means to achieve a worthwhile reduction in the costs of operation by the adoption of simple technical solutions and particularly by intensive

organisation of operation and maintenance, rather than by expensive improvements which may certainly be beneficial in theory but are often financially difficult to justify in practice.

This attitude is shown throughout the reports by Messrs Diegoli and Long, the salient points of which are set out below :

A. Increased boiler pressure.

a) *Standard type of boiler.*

At the Paris Congress, it was accepted that a pressure of about 20 kg/cm² (284 lbs/sq. in) should be considered as the current upper limit for boilers of the normal types.

This conclusion does not seem to have been sanctioned by facts : apart from some exceptions, the Administrations consulted were of the opinion that it would be wise to keep to 16 to 17 kg/cm² (227 to 241 lbs per sq. in), as higher pressures led to difficulties in service, which increased maintenance costs and due to the necessity for keeping the weight of the boiler within acceptable limits, very often involved the use of special steels which in itself was a cause of frequent difficulty.

The S.N.C.F., however, report that they have 500 locomotives pressed at 20 hpz with boiler plates of weldable nickel steel (2.5 % Ni) which have been subject to no defects other than those normally experienced and of comparable frequency and severity. They are of the opinion that for powerful locomotives this pressure, and even a pressure of 22 hpz is perfectly admissible.

b) *High pressure boilers.*

Of all the special locomotives with high pressure boilers which were being designed in 1937, none has passed the experimental stage and they may be considered abandoned.

B. Types of grate.

a) **Coal firing.**

— *Grates.*

Fixed and rocking grates are both in current use with a great diversity of types, which differ in the form and proportion of air inlets.

These grates are generally of cast or hæmatite iron with a small percentage of phosphorus.

The area of the grate available for the free passage of air is very variable according to the type of grate (17 to 50 %) and fuel used.

— *Arches.*

Most modern locomotives are provided with an arch to reduce the amount of fuel drawn into the tubes and to increase the life of the firebox.

Arches are generally as long as possible bearing in mind the needs of inspection and maintenance of the tube plate and the area of passage needed for the combustion gases, between the arch and the firebox crown. This passage area must be greater than that of the boiler tube nest.

— *Hand firing and mechanical firing.*

The currently permissible limit for hand firing, which varies according to the type of locomotive and kind of service undertaken, is located at a grate area of about 5 m² (53 sq. ft.) and an average rate of firing of about 2 tons/hour although this rate can be exceeded for short periods.

On the more powerful locomotives use is made of mechanical stoking. The various Administrations which have had experience with it consider, however, that it entails a certain increase in consumption, of the order of 5-10 %.

b) **Firing with pulverised fuel.**

Pulverised fuel firing has been completely abandoned.

c) **Firing with fuel oil.**

Fuel oil firing is not very widespread amongst the Administrations which have replied to the questionnaire. Although it has been extended since 1937, it appears to have had only limited application

according to the relative economic position or the current supply possibilities. Oil-fired locomotives are often reconverted to coal firing as soon as possible.

C. Superheating of steam.

The superheat temperature of 400° C considered at the Paris Congress to be the maximum compatible with good lubrication and satisfactory behaviour at high temperature of the metals in contact with the steam is still regarded as the most suitable in practice, although it already demands specially adapted lubricants and the use of improved cast irons for piston segments.

No new arrangements are reported in connection with superheater elements; the back bends of these elements are usually located about 400 mm (1′ 3 3/4″) from the firebox tube plate.

The drop in steam pressure between the boiler and the valves is normally between 1 kg/cm² (14 lbs per sq. in) for well designed steam circuits.

There are few arrangements for preventing water from being drawn from the boiler to the superheater.

Lubrication of valves and pistons is generally effected by mechanical lubricators fitted with non-return valves at the end of the feed pipes. Consumption of oil varies considerably betwen railways.

Piston valves are generally fitted with cast segmental rings or with segments with a large area of contact made of special castings and bronze; the use of such segments eliminates the need for a tail rod.

Piston rod packings of metallic segments either in soft perlitic cast iron or lead bronze are widely used in various designs.

D. Preheating of the feed water.

Whilst feed water preheaters using exhaust steam, injectors or preheaters are widely used amongst the European Administrations, this is not the case with other Administrations, mainly because of the additional maintenance involved.

In Europe, pump type preheaters are more favoured than exhaust steam injectors; mixer type preheaters are replacing surface types in modern locomotives.

The Administrations assess the economies due to the use of exhaust steam injectors at :

about 10 % saving of coal;
about 8 % saving of water.

In addition to exhaust steam preheaters, it is appropriate to mention the combustion gas preheater, Franco-Crosti type, fairly widely used on the Italian State Railways and recently applied experimentally on the German Federal Railways. This preheater effects a saving in coal of about 15 to 20 %; it involves, however, considerable installation charges, tends to make the locomotive much heavier and often gives rise to excessive back pressure in the exhaust.

E. Treatment of the water.

All Administrations are proceeding with line-side chemical water treatment; trials with physical line-side treatment have been found profitless and this type of treatment has been abandoned generally.

Water is treated either in fixed plants or, in an increasing measure, in locomotives themselves. On some Administrations, the two methods are combined.

With direct treatment in the boiler, the reagents are introduced into the tender tanks whevever water is taken or even added in the supply pipe at the watering point.

Direct boiler treatment necessitates fairly frequent blow down to eliminate sludge in suspension and reduce alkalinity of the water. This can be done by sluice valves which provide either continuous automatic blow-down or — as seems to be preferred — an intermittent blow-down operated by the driver when running with open regulator. The extraction rate is generally about 4 to 5 % of the water evaporated.

The Administrations unanimously acknowledge the appreciable advantages re-

sulting from water treatment, which are shown in :

— a notable increase in wash-out periods;

— an important reduction in boiler maintenance;

— increased regularity of service and more intensive use of locomotives.

Some minor drawbacks, which can however be overcome at least partially, are also reported : priming, corrosion of certain parts (lead plugs, bronze cocks, gauge glasses).

In all cases, it is recognised that permanent strict control of the application of water treatment is necessary to obtain full benefit from it.

F. Lagging of boilers.

Most Administrations incline to full lagging of the boiler. The results in regard to thermal insulation and life are considered satisfactory.

G. Exhaust.

No Administration reports the use of a variable exhaust.

With regard to fixed exhausts, the European Administrations are continuing to use, instead of the normal exhaust with single blast pipe, exhausts of more recent design : Kylchap, Giesl, etc.

The S.N.C.F., in particular, report that comparative trials with its 141 R locomotives of American build, with normal and Kylchap exhausts, have shown that the latter, whilst reducing coal consumption per HP/h allows an increase in the maximum power of the locomotive.

Other railways on the contrary, prefer the normal exhaust; they seek to improve this exhaust and achieve uniform draught over the whole of the tube-plate by a judicious arrangement of the blast pipe in the smokebox also by giving it the most suitable proportions.

H. Distribution.

All the Administrations agree in preferring the standard Walschaerts gear with piston valves to any more improved system.

The reasons mainly given are simplicity, accessibility and ease of maintenance.

Only in some special cases, very high speed locomotives, or those which run long distances with closed regulator, do poppet valve gears appear to have certain advantages.

Amongst the types in use, oscillating cams appear to be preferred to rotary cams because of their more stable operation and greater resistance to wear.

The use is also reported by certain railways of piston valves which include an automatic by-pass to facilitate running with closed regulator.

I. Miscellaneous.

a) *Condenser for exhaust steam.*

Amongst the railways which have replied, only the South African Railways have condensing locomotives. These locomotives are designed for traffic on a line where water supplies are insufficient.

The other railways consider that condensing locomotives are too costly, cumbersome and complicated, and too difficult to maintain to allow them to be given consideration except for very special reasons.

b) *Circulation of water in the boiler.*

The use of Nicholson syphons, arch tubes, etc. is viewed by Administrations with some mistrust; their advantages being offset by the disadvantages they may involve.

c) *Steam circuits.*

The conclusions formulated in this respect at the Paris Congress remain valid; amply dimensioned steam passages are necessary to reduce the pressure drop between boiler and cylinders.

d) *Preheating the air.*

No Administration reports experience of preheating the air.

e) *Compounding the engine.*

The almost unanimous opinion of the Administrations is against compounding because of the more complicated mechanism and the higher maintenance costs involved, despite the higher thermodynamic efficiency which can be achieved.

f) *Streamlining of locomotives.*

Total streamlining of locomotives as advocated at the Paris Congress has today been abandoned in favour of a simplified form covering only the more outstanding projections to improve accessibility of the interior parts and the cooling of the axleboxes and motion.

It also appears that total streamlining may only be beneficial at speeds about 120 km (74 miles)/h.

L. Utilisation and maintenance of locomotives.

Administrations wishing to intensify the use of their steam locomotives are relying more and more on multiple, double or triple crews, or even on completely common usage of engines.

The annual mileage of locomotives at present reaches 80 000 to 90 000 km (49 700 to 56 000 miles) and even 145 000 (90 000 miles), with certain types of passenger locomotives on the German Federal Railways.

The longest runs without change of engine are in Europe 525 km (326 miles) (Germany). In other continents, they reach 1 465 km (910 miles) on the S.A.R., and 765 km (475 miles) on the I.R.

The tonnages hauled, in Europe, go up to 800 tons on passenger trains and 1 750 tons on freight. In Africa (S.A.R.), there are trains of 1 430 tons on main lines.

Maintenance costs vary according to the railway from 35 to 100 fr. fr/km in Europe and from 20 to 50 fr. fr/km in Africa and India.

M. Power and efficiency of modern locomotives.

The diagrams and tables appended to the reports by Messrs DIEGOLI and LONG show the results obtained with the locomotives most recently put into service by the Administrations.

Study of these data allows one to conclude that no noticeable progress has been made since 1937 in connection with efficiency of output. This remains in the region of 7 to 9 %.

N. Present position of the locomotive in relation to other types of traction and future prospects.

Despite the development of electric and Diesel traction, steam locomotives still represent the great majority of motive units on most of the Administrations.

The general tendency is, however, clearly directed towards the replacement of steam traction by another and more economic type : electrification of main lines with heavy traffic and lines radiating from large centres, extension of Diesel traction for shunting, secondary line services and fast, light trains for long distance services.

The construction of new steam locomotives has dropped greatly because of this tendency.

With regard to the present stock of steam locomotives, this is likely to diminish progressively in future years, but its elimination is not imminent because of the capital investment necessary to replace steam by another form of traction.

Summaries.

1. — Steam traction is being progressively displaced by other types of traction, and little new steam locomotive construction is now envisaged.

In view of the size of the stocks of steam

locomotives which will have to remain in service for many years to come, the main aim of the Administrations is to reduce to a minimum the cost of operation and to increase the availability of engines by improvement and especially by simplification.

It would appear that in the search for a lower cost for a steam locomotive, there is more to be gained in the present state of steam locomotive technique by a reorganisation of the locomotive's service than by improvement of the engine.

2. — The normal type of boiler has prevailed over all the special types previously envisaged.

To avoid any increased cost of maintenance, boiler pressure has generally been maintained at 16-18 kg/cm² (227-256 lbs per sq. in) and temperature of the superheat does not exceed 400° C.

3. — Various types of grate (fixed or movable) are used on all locomotives. None of these types appears to be particularly outstanding.

4. — Mechanical stoking is well developed for powerful locomotives having a grate area of more than 5 m² (53 sq. ft.). It is advisable in spite of the resultant expense. It also allows fuel to be used which is not very suitable for hand firing.

Oil firing has been extended, but its development depends mainly on the comparative economic market in fuel oil and coal.

5. — In spite of increased maintenance costs, feed water preheating is widely used.

Mixer type, pump preheaters are generally preferred to other types of preheater.

6. — Feed water treatment is done in fixed plants or in the boiler, the latter being in some cases complementary to the former. Direct treatment of water in the boiler seems to be developing. It offers in general in common with the combined treatments mentioned, considerable advantages as regards reduction in boiler maintenance and repair, increased locomotive availability and reduced consumption.

7. — There is a tendency shown in favour of complete boiler lagging. No systematic trial has so far been effected to permit a conclusion for or against it.

8. — No new tendency has been shown in recent years with regard to the various types of exhaust used on steam locomotives. Variable exhausts tend to disappear.

9. — Cylindrical piston valves with Walschaerts gear prevail, by reason of their simplicity and ease of maintenance.

Poppet valves are used only in special cases (high speeds).

10. — Despite the thermodynamic advantages which may result from the adoption of compounding, there appears to be a very clear tendency in favour of simple expansion because of the greater simplicity of the mechanism.

11. — Air preheating, condensers and thermic syphons are little used and in all cases only in special circumstances.

12. — Annual mileages of locomotives have been considerably increased and now attain 80 000 to 90 000 km (49 700 to 56 000 miles); this is due to the development of multiple crew services, double or triple crews and even completely common usage.

SECTION III. — Working.

[656 .254]

QUESTION 5.

Radiophonic communications in railway working,

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Special Reporter.

INTRODUCTION.

Two reports, as under, have been presented on Question 5 :

Report (America (North and South), Australia (Commonwealth of), Burma, Ceylon, Denmark, Egypt, Finland, India, Indonesia, Irak, Iran, Republic of Ireland, New Zealand, Norway, South Africa, Sweden and the United Kingdom of Great Britain and Northern Ireland and the territories for whose international relations the United Kingdom is responsible), by S. G. HEARN and J. H. FRASER. (See *Bulletins* for September 1953, p. 615, and October 1953, p. 709.)

Report (Austria, Belgium and Colony, Bulgaria, Czechoslovakia, France and French Union, Germany, Greece, Hungary, Italy, Luxemburg, Netherlands, Poland, Portugal and Colonies, Rumania, Spain, Switzerland, Syria, Turkey and Yugoslavia), by J. FRISCHAUF. (See *Bulletin* for April 1954, p. 405.)

The use of radio communication by railways has not previously been the subject of an independent Question at a meeting of the Congress, although brief references have been made to the subject in other reports, especially those relating to marshalling yard practice.

A large amount of data was supplied by the participating administrations, in response to a questionnaire, as to the purposes for which radio-telephony is being used on the railways, with information as to the difficulties encountered in its application, and particulars of frequencies and apparatus employed. These matters have been dealt with fully in the two reports.

The primary object of this special report is to review briefly the salient features in those reports and to submit a summary of conclusions derived therefrom. As Question 5 is included under Section III, — « WORKING », of the Agenda for the London Congress, this special report is being prepared with a minimum reference to technicalities.

Apart from the uses described herein, certain administrations utilise radio-telephony to and from water-borne craft, but as this form of communication is in general use for shipping, it is felt that this feature does not come within the scope of this report and no further reference will be made to it.

Whilst experiments were made before the second world war, it was not until after the termination of the war — during which rapid advances were made in the technology, development and harnessing of the short waves — that radio-telephony was made available to the railways to any appreciable extent.

For several aspects of railway working,

the use of radio has passed beyond the experimental stage, and in some countries, particularly the United States of America, it has been widely adopted in regular day-to-day operations as a permanent feature.

The working of a railway requires a high degree of co-ordination of the movements of men and vehicles at continually changing locations, and the advantages derived from being able to keep in constant touch with locomotive or train crews and for mobile units to communicate one with another, have been the main reasons for the introduction of radio communication on railways in recent years.

In addition, radio may, under some special circumstances, be a cheaper and safer alternative means of providing communication between fixed stations.

Where circumstances are favourable to its introduction, radio-telephony is capable of increasing efficiency and enhancing the speed of working. There is scope not only for its further adoption in fields where its value and usefulness have already been proved, but there may be other spheres in which radio can be employed to reduce costs, thereby assisting managements in meeting the growing competition of other forms of transport. Developments and technical advances in this relatively modern method of communication should receive the attention of railway administrations.

COMMUNICATION WITH AND ON TRAINS EN ROUTE.

(i) End-to-end communication.

Radio-telephony is used more extensively in the U.S.A. than elsewhere for communication between front and rear ends of long freight trains where members of the crew may be separated by over a mile and the exchange of hand signals is difficult. In such circumstances, radio communication is of value in a variety of conditions : it saves time and contributes to the safety and efficiency of operation.

This method has been applied to a limited extent in some European countries.

Radio communication has also proved beneficial between train engines and banking or assisting engines to co-ordinate their movements.

(ii) Between moving trains.

When end-to-end communication on trains on a railway is carried out on the same frequency, it enables communication to be established between one train and another, which can be used to pass information of conditions likely to endanger a train running on the same or a parallel track.

Under certain conditions, supervisory officials with radio-equipped automobiles, or, possibly track cars, may have need of communication directly with trains in their vicinity.

(iii) Between fixed points and trains.

With the train dispatch system of working, radio-telephony permits train crews to report to the dispatcher as to the location of, and exceptional conditions relating to, their trains, so enabling the dispatcher to co-ordinate movements in the most efficient manner and to make decisions quickly in the case of mishap or unusual occurrence.

Some installations provide the facility whereby a mobile station can be connected automatically at the nearest fixed radio station to a land line circuit, so that the mobile station can communicate by radio link and land line with a dispatcher who may be 100 miles or more distant.

On long branch or secondary lines of single track where land line telephones may be non-existent or remotely located, radio communication can be used to advantage for the purpose of advising the controlling point of any untoward happening and of summoning assistance when required.

(iv) Between trains and members of the train crew on the ground.

Quite often it is necessary for a member of a train crew to investigate defects on a

long freight train. The equipping of the train crew with portable radio sets enables instantaneous communication to be established with the driver or guard and facilitates the execution of whatever measures are found necessary to correct the trouble, particularly if conditions are such as to render the use of hand or hand-lamp signals unreliable.

Similarly, when the guard goes back to protect his train, he can speak to his own or an approaching train.

MARSHALLING YARDS AND TERMINAL AREAS.

(a) Marshalling yards.

The efficiency and speed of working in a marshalling yard is largely dependent upon the character of the appliances provided to transmit and receive instructions. Radio-telephony is already extensively employed and is being introduced on a growing scale, particularly in the U.S.A. and to a lesser extent in some European countries, as a supplementary aid to establish communication with drivers of locomotives or individuals whose duties require them to be mobile. Such communication can lead to savings in locomotive and man hours, reductions in the number and gravity of mishaps, and a speed-up in shunting operations and the clearance of sorting sidings.

The quicker passage of wagons through a yard increases its capacity and may, in some circumstances, obviate the necessity for additional sidings or extension of signalling.

In the case of new yards, it is possible that, by the use of radio, the number of shunting signals and loudspeakers may be curtailed, so reducing initial and maintenance costs.

The introduction of radio in marshalling yards is simplified by there being few, if any, transmission difficulties because of the limited distances involved. The method of application most widely adopted is between a fixed point and locomotives engaged on shunting operations, especially for regulating the speed of propulsion over a hump or in a flat yard.

In connection with the marking of wagons prior to sorting, French and German Railways have obtained good results from radio links between the man doing the marking and the hump cabin or other fixed point.

Yard supervisory staff engaged in making up trains are, in some yards, provided with portable radio sets enabling communication to be maintained with drivers and the Yard Office.

There are several variations of the principle : for instance, when wagon examiners are equipped with mobile sets they are able to report instantly any defective wagons or bad loads found, so expediting the application of remedial measures; also to intimate when the inspection is complete; either of which process may previously have involved a long walk to a telephone. At some places, messages are reproduced on the paging-type loudspeakers and are thus heard by others who may be working on the train or are concerned in other ways.

Another method of saving time where detailed recording of the composition of trains is necessary before departure, is for the checkers or number-takers to walk alongside the train and by means of a portable radio transmit to the Yard Office the initials, numbers, and destinations of the vehicles. This system is also applied to arriving trains, a checker standing at one end of the yard as a train comes in and calling off the numbers of the vehicles as they pass by. A refinement of these systems is the provision of automatic recorders in the Yard Offices enabling the transcription of messages to be performed as occasion requires.

Radio may also be applied with advantage for the purpose of controlling locomotive movements in parts of marshalling yards where such control would normally be exercised by signals of the semaphore or colour light type, but where it is impracticable for physical reasons to locate such

fixed signals so as to give adequate visibility at all times and in all circumstances.

Under conditions of poor visibility when signals cannot readily be seen, radio-telephony is of even greater value in facilitating the transmission of instructions in marshalling yards. In fact, the extent to which fog and snow or other adverse climatic conditions are experienced is an important factor in determining whether or not radio should be introduced at a particular place.

In Great Britain, there are some yards where certain instructions are conveyed to drivers of shunting locomotives by means of a simple code of audible signals given by electric bells, klaxon horns or mechanical gongs, located in the open alongside the shunting line and operated from a distance by button, plunger or lever. In some instances this method is in force regularly, but in others it is only brought into use during fog or falling snow.

Hitherto, this method of transmitting audible signals in connection with shunting movements has met requirements, but with the growth in the number of diesel electric shunting locomotives, a difficulty has come to light recently in that drivers cannot rely upon hearing the signals owing to the humming noise inherent in that type of engine and the more enclosed character of the cab compared with that of a steam engine.

Investigations are in progress as to alternative means of overcoming the difficulty, including the possible application of radio, but the latter envisages either the equipping of the locomotives with aerials, suitable electrical connections and the necessary radiophonic apparatus, or the development of a suitable and readily portable complete outfit, since locomotives have necessarily to be changed at times for fuelling and maintenance purposes, and there are also occasions when a steam locomotive may have to be utilised at short notice for shunting.

(b) **Terminal areas.**

In the environs of large cities and towns, there are usually several traffic yards and depots, as well as siding-connected factories, between which transfers of loaded and empty wagons are necessary, and locomotives, guards and shunters have perforce to perform shunting operations at some distance from their base. Similar conditions exist in extensive dock and harbour areas.

It is customary to lay down scheduled workings for the trip engines so far as this is practicable, but variations inevitably arise in the volume of traffic to be dealt with from day-to-day, and urgent requirements have to be catered for. A considerable amount of waste movement and time can be avoided and greater efficiency attained by employing radio between a central supervisory point and the locomotives.

It is a matter for consideration whether this system could be applied with advantage in areas where there is intensive trip working; for example, in districts where there are many collieries.

ENGINEERING OPERATIONS AND ANCILLARY SERVICES.

On new railway construction projects, good results have been obtained by providing radio equipment to facilitate contact between the resident engineer, section engineers, and the gangs, and between different sections of one gang. This not only enables economies and greater efficiency to be achieved by reason of the closer co-ordination of men, materials and equipment, but assists in the interchange of messages between members of gangs working some distance apart on tasks which are inter-dependent.

The possession of portable radio apparatus by men working on major signalling schemes enables tests to be made with a minimum of delay.

Several administrations provide gangs working on maintenance of the track, electrical overhead equipment and signalling, with radio to enable different groups of men to maintain contact with one another and to link the gangs with traffic depart-

ment posts. This practice has been found of especial value where gangs are equipped with the means of travelling quickly from place to place, or are working over a considerable length of track. It is claimed that the system minimises the time lost by interruption of work during the passage of trains.

Maintenance of electrified lines in urban areas has been assisted by the provision of radio sets in road motor vehicles equipped with breakdown materials. Such a method enables the skilled staff and their equipment to be employed on normal construction and maintenance work in the ordinary course, and avoids the necessity for keeping vehicles and men standing by at depots solely for emergency purposes.

Radio is employed in the U.S.A. when clearing lines in the case of accident, and for controlling the movements of snow fighting equipment.

Having regard to the extent to which radio is employed by Civil Police Forces, Fire Brigades, and for maintaining contact with taxicabs and other road vehicles, it is somewhat surprising that this medium is not more widely used for the control of railway-owned collection and delivery vehicles, there being little evidence of its use for this purpose. This appears to be a field in which radio could be employed to reduce mileage, summon assistance in the event of breakdowns or accidents, direct vehicles to pick up urgent consignments, and generally to give a better commercial service.

The New South Wales Government Railways have found that beneficial results have accrued from the use of radio-telephony by their Police in the prevention and detection of thefts from railway vehicles and premises. Statistics indicate that many more convictions have been obtained, which have served as a deterrent to others, with a consequent falling off in thefts, and it has also been found possible to utilise the detective force to greater advantage.

A few railroads in the U.S.A. provide a radio-telephone service for passengers on moving trains to make or receive a call connected to any point on the public telephone network or with other moving trains so equipped. The provision of such a service is largely influenced by the distances traversed by the trains and commercial considerations. Experience shows that owing to the cost and the limited demand by the public for the facility, the service is generally run at a financial loss to the railroad. Experiments of this nature were conducted by the Canadian and Belgian Railways but were abandoned for economic reasons.

COMMUNICATION BETWEEN FIXED POINTS.

On the face of it, the idea of utilising radio for communication between distant points is an attractive proposition. There are several countries where it is permitted, and is in regular use. This is particularly the case where vast distances are involved and where land line channels are not available or are inadequate to meet the needs. In some parts of the world, owing to topographical reasons and extremes of climate, land lines are very costly and difficult to install and maintain, and in others are subject to sabotage. In such circumstances, the use of radio may obviate the necessity for erecting long stretches of aerial wires or the laying of cables, and reduces the risk of breakdown in communications.

In countries where new or additional long-distance communication is required and no difficulty is experienced in procuring licences, it would be worth while to investigate the relative costs of establishing radio systems as against the different methods of providing land line communication.

Unfortunately the radio channels necessary are not readily obtainable in densely populated and highly industrialised countries, preference being given to government-controlled radio communication, broadcasting, and the requirements of shipping, navies, armies, air forces and civil aviation,

this being one of the reasons why, up to the present, wireless has not been more extensively used between fixed points for railway purposes.

Recent developments in microwave technique have, however, opened up a new field in that they provide multi-channel systems which can all be transmitted on one radio beam. These systems may be particularly advantageous under the conditions mentioned in the first paragraph of this section, and whilst they are expensive to install, they might also be justified where there is a considerable density of message traffic between two particular stations.

Some microwave frequencies have already been made available to railroads in the U.S.A. for point-to-point communication, on a shared basis with other radio services. These have been introduced in regions where the telephone lines are frequently severed owing to severe snow and sleet storms, also to establish communication across water and avoid a circuitous route by land.

LICENSING.

In view of the many demands on the frequencies available and the growth in the uses to which radio is being put, it is essential that there should be governmental control of the issue of licences to operate in the respective countries. Nations also have to agree on the allocation of frequencies for their mutual protection from overlapping and interference. It is, therefore, a requirement in all countries that licenses to operate radio stations for railway purposes must be obtained from the appropriate authority, which is usually that which controls the telecommunications services of the country. Consequently the frequencies allotted and the signal strength permitted to railways govern the character of the service in which they can be employed and the method of their utilisation.

Following the development of the short waves during the last decade, the railways have been allotted a greater number of channels in the higher frequency bands, the characteristics of which, whilst limiting the range, minimise interference and enable the same frequencies to be employed simultaneously in different localities.

For the reasons already stated, the use of radio for communication between fixed points has been discouraged by the licensing authorities in several countries, but it is possible that they will look with greater favour on the introduction of microwave systems for such a purpose, in view of the greater number of channels available and the reduction of interference with other radio services which beamed transmission affords.

APPARATUS.

It is an advantage for each railway to keep to a minimum the number of types of apparatus employed in order to ensure the greatest measure of interchangeability of sets and component parts.

Manufacturers have, in conjunction with railway administrations, developed many excellent types of transmitting and receiving apparatus suitable for fixed, mobile and portable uses. The essential qualities of such equipment for railway purposes are that it must be robust and compact. In the case of mobile apparatus it must also be water and dust proof, and capable of withstanding mechanical stresses.

A high degree of reliability with radio equipment in service has been attained, railways in the U.S.A. and Belgium having compiled statistics indicating an availability of approximately 99 per cent.

There has been a tendency for the size and weight of radio sets of all types to be reduced in recent years without any sacrifice of robustness. Developments in this direction are desirable and should be encouraged.

Portable sets have been produced which are light and do not impede the movements of staff working on the line or in sidings; but if, as a result of further reduction in size, the type of set as used on locomotives and trains can be made even more readily

transportable, permitting easy transfer from one vehicle to another, it may be possible to introduce radio in places and for purposes where it is not yet a practical proposition.

The form of aerial employed is determined by the purpose to be served by the particular radio link. Many types are used and it is fortunate that the frequencies allocated to railways for mobile purposes are, in most cases, sufficiently high to enable reasonably compact arrays to be provided.

Aerials on railway vehicles must be of special types to keep within the permitted clearances and be protected against high tension contact wires. Any difficulties there may have been in this respect seem generally to have been overcome, and the limitations imposed by the loading gauge have not had any serious effect on radio communications.

Communications with mobile units is adversely affected by tunnels, deep cuttings and valleys bounded by high mountains. Many tests and experiments have been carried out in different countries, but at present the continuity of radio signals is only possible by using special equipment.

The provision of power supplies, both for fixed and mobile stations, does not present any insuperable difficulties.

GENERAL.

As a general rule, radio is used to provide communication of a character not practicable by physical means, and has not superseded existing methods of communication. On the contrary, the general statement is that radio is supplementary to the main telecommunications systems, this being qualified only to the extent that it is proposed in some countries to dispense with shunting signals when constructing new marshalling yards.

As matters stand at present, reliance could hardly be placed solely on radio-telephony for regulating the movements of trains on running lines, having regard to the hazards involved in failure to receive a message or to instructions so conveyed being misunderstood. At the same time, it is desirable to keep an open mind on the subject, as it is impossible to forecast ultimate developments in the application of the principles of radio, which may, at some stage in the future, render it advisable for reconsideration to be given to the generally accepted methods of working.

There is greater opportunity for radio to take the place of some existing means of communication in activities where instructions are already given verbally.

No evidence is forthcoming, as yet, of the successful application of radar to train working. A form of radar is utilised in a few marshalling yards in the U.S.A. to determine automatically the speed of vehicles during shunting.

SUMMARIES.

A. — Introduction.

1. — The potentialities of radio for communications with and between mobile units have been the main reason for development of this form of communication in some countries during the last 10 years.

2. — In addition, radio may under some special circumstances be a cheaper and safer alternative means of providing communication between fixed stations.

3. — Technical advances in this relatively modern method of communication should receive the attention of railway administrations.

B. — Communication with and on trains on route.

4. — Radio-telephony is used more extensively in the U.S.A. than elsewhere. It is used there for communication between the front and rear of long freight trains where exchange of hand signals would be difficult, or with banking or assisting engines to co-ordinate their movements.

5. — Radio also enables one train to report dangerous conditions to another.

6. — With the train dispatch system of working, the train crews can report to the dispatcher and he can co-ordinate their movements more easily.

7. — If train crews have portable radio sets, defects on a long freight train can be reported to the driver or guard by a member of the crew. Also when the guard goes back to protect his train he can speak to his own or an approaching train.

C. — Marshalling yards and terminal areas.

8. — Radio-telephony is used in marshalling yards :

a) Between some central supervisory point such as a Yardmaster's office and locomotives in the yard.

b) Between the person in charge of propelling movements over a hump and the driver of a locomotive engaged on humping operations.

c) Between inspectors, foremen or shunters and drivers of locomotives engaged on shunting operations in other parts of the yard.

d) To and from wagon examiners where speed is desirable in reporting defective wagons or bad loads.

e) To and from checkers or number-takers where detailed recording of the composition of trains is necessary.

9. — Under conditions of poor visibility, even greater advantages are secured in connection with the above uses (par. 8 *a* to *e*).

10. — Reliable radio communication can lead to savings in locomotive and man hours, reductions in the number and gravity of mishaps, and a speed-up in the clearance of sorting sidings. The quicker passage of wagons through a yard increases its capacity and may, in some circumstances, obviate the necessity for additional sidings or extension of signalling.

11. — In terminal areas a considerable amount of waste movement and time can be avoided and greater efficiency attained by employing radio between a central supervisory point and locomotives serving distant depots, dock areas, factories, and other siding-connected undertakings.

D. — Engineering operations and ancillary services.

12. — When radio-telephony is employed to link railway construction gangs and maintenance gangs on track, electrical overhead equipment and signalling, with engineering supervisors and traffic department posts, closer co-ordination and utilisation of men, materials and equipment is possible.

13. — Advantages are obtained by the use of radio-telephony when clearing lines in the case of accident, and for controlling the movements of snow ploughs, etc.

14. — Although experiments have been made, little evidence is forthcoming of the application of radio-telephony to the control of railway-owned road collection and delivery vehicles. This appears to be a field in which radio could be employed to reduce mileage, summon assistance in the event of breakdowns or accidents, direct vehicles to pick up urgent consignments, and generally to give a better commercial service.

15. — The use of radio by railway police has assisted in the prevention and detection of thefts from railway vehicles and premises.

16. — The provision of a radio-telephone service for passengers to and from the public telephone system is largely influenced by the distances traversed by the trains and commercial considerations.

E. — Communication between fixed points.

17. — The use of radio for communication between fixed points is worthy of consideration where :

a) Great distances have to be covered involving the erection of long stretches of aerial wires or laying of cables.

b) Telephone lines are costly and difficult to maintain owing to topographical or climatic conditions.

c) Communications are subject to sabotage.

18. — Beamed radio using microwave technique may be particularly advantageous for these conditions. While these systems are expensive, they might be justified where there is a considerable density of message traffic between any two particular stations.

F. — Licensing.

19. — In all countries, licenses to operate radio stations have to be obtained from the appropriate authority in control of the telecommunication services of the country. Consequently the frequencies allotted and signal strength permitted to the railways govern the character of the service in which they can be employed and the method of their utilisation.

20. — In some countries the licensing authorities have discouraged the use of radio for communication between fixed points, owing to the requirements of national and public services such as aviation, broadcasting, etc., for which no other form of communication but radio is practicable.

21. — It is possible, however, that in such cases licensing authorities will look with greater favour on the introduction of microwave systems for fixed point-to-point communication in view of the greater number of channels available, and the advantages gained by utilising beamed transmission to reduce interference with other radio services.

22. — In general, the frequencies allotted to Railway Administrations are in the very high frequency band (VHF) or above. This, whilst limiting the range, minimises interference and enables the same frequencies to be employed simultaneously in different localities.

G. — Apparatus.

23. — Radio equipment for railway purposes must be robust and compact and in the case of mobile stations, waterproof.

24. — Recently the size and weight of radio sets of all types have been reduced, and developments in this direction should be encouraged. If equipment of a more readily transportable character were available, it would facilitate the introduction of radio in places and for purposes where it is not yet a practical proposition.

25. — Aerials on railway vehicles must be of special types to keep within the permitted clearances and be protected against high tension contact wires. The limitations imposed by the loading gauge have not had any serious effect on radio communications.

26. — Continuity of radio signals in long tunnels, deep cuttings and valleys bounded by high mountains is only possible today by using special equipment.

[656 .257]

QUESTION 6.

A) Remote operation of signal boxes : technical realizations, working orders.

B) Electric working and control devices for hinged and « flexible » points and switches.

Control of accidental trailing of the switch blade,

by Jules NOGUÉS,

Sous-Directeur du Réseau National des Chemins de fer Espagnols.

Special Reporter.

Question 6 has been the subject of the three following reports :

a) Report (America (North and South), Australia (Commonwealth of), Burma, Ceylon, Denmark, Egypt, Finland, India, Indonesia, Irak, Iran, Republic of Ireland, New Zealand, Norway, Pakistan, South Africa, Sweden and the United Kingdom of Great Britain and Northern Ireland and the territories for whose international relations the United Kingdom is responsible), by R. SØRVIK (See *Bulletin* for August 1953, p. 495).

b) Report (Belgium and Colony, Spain, France and French Union, Greece, Italy, Luxemburg, Netherlands, Portugal and Colonies, Switzerland, Syria and Turkey), by J. NOGUÉS (See *Bulletin* for October 1953, p. 801).

c) Report (Austria, Bulgaria, Czechoslovakia, Germany, Hungary, Poland, Rumania and Yugoslavia), by Prof. A. DOBMAIER (See *Bulletin* for November 1953, p. 923).

The object of the present report is to summarise the leading ideas and particulars contained in the three main reports before mentioned, and to endeavour to deduce conclusions therefrom.

A list of questions drawn up by agreement between the three reporters was sent out early to all the managements concerned. It was of an extensive and detailed character, containing about 200 questions. This has allowed of an interesting amount of material being collected, forming a most valuable source of information. In the present summary, however, it has been necessary to leave aside numerous questions of technical detail and limit it to showing what are the ruling tendencies noticeable in matters of principle, having a general bearing on the subject on the basis of which, as we think, the discussions and summaries relative to Question 6 will require to be based.

As regards remote control, it is to be noted that the United States excepted, the experience of the greater part of the managements which have replied to the questionnaire (eight systems) is not at all conclusive, on account of the small number of installations in service on their railways and which have been in operation for only a short period. These circumstances may therefore affect to a slight extent the value and general significance of the summaries derivable from the information brought together by the reporters.

PART I.

Remote control of signalling installations : engineering details.

Application of remote control.

Remote control of signalling installations is being extended in two distinct forms, which themselves tend to exhibit the difference between the different processes of effecting such control, namely : *a*) remote control of all station layouts *throughout an entire length of line,* known as centralised traffic control (C.T.C.); and *b*) remote control of locations in the outer areas of large stations, or at junctions and crossings, etc., operated from a nearby station.

C.T.C. installations along a length of line have been developed on a much larger scale on the American railways than in any other country. According to information supplied by the *Association of American Railroads (A.A.R.)* there are 16 543 miles (26 622 km) of line equipped with C.T.C., the greater part being single. It is agreed that C.T.C. increases both the flexibility and capacity of the working, as compared with that obtainable with the « train order » system of operation, generally used in the United States. In that country also the installing of C.T.C. generally involves substituting the manual operation of the points by train crews by the electrical operation under remote control and the addition of adequate signalling. These measures, indispensable for the establishment of C.T.C. contribute to the good results obtained, such as increased safety, reduction in number of stops and time lost, saving of train hours. In short, greater traffic capacity and a certain economy in working expenses. As the particulars furnished by the *A.A.R.* show, C.T.C. has sometimes allowed of tracks being disposed with by reason of the increased capacity provided on the remaining track or tracks.

In other countries, and in particular in Europe, the same circumstances are not met with as a rule : trains meet and overtake each other nearly always in stations where staff is on duty, dealing with both the commercial and operating services, circumstances which arise from the very different general conditions obtaining. On the other hand, there are very often traffic controller's offices dealing with long sections of route, concentration of the operation of points and signals in a great number of stations and at times automatic signalling.

The advantages to be gained from C.T.C. are therefore less and will in fact depend on the conditions existing previously as regards installations already in use and the way in which the working is organised. The specific advantages of C.T.C. in such circumstances can become limited to those coming from the elimination of time lost between the giving of orders by the traffic controller and the carrying out of them by the stations and to the quicker and more exact furnishing of information by the C.T.C. equipment regarding the positions of the trains.

This diversity of conditions explains the smaller development attained by C.T.C. in Europe, when applied to an entire length of line. However, certain installations on sections of single line carrying very heavy traffic are being carried out by Belgium (OTRACO in the Belgian Congo), and in Spain and Italy, trials deserving of being followed with interest and attention.

Several managements consider that C.T.C. is especially to be recommended on double track lines when it is a question of making each line available at will for traffic in either direction with a view to obtaining greater carrying capacity or avoiding having to triple or quadruple the tracks. This is the case in two important installations carried out in France by the S.N.C.F. In Germany, the D.B. has commenced to make installations of C.T.C. on *double track lines,* without making this a question of obtaining common user of tracks in both directions, but in order to increase the capacity and flexibility of working and avoid having to lay down the additional tracks which would otherwise have been required.

The application of remote control to isolated layouts opens up a new and wide field which appears capable of becoming of very great interest, as a means of enlarging economically the area controlled from a signal box and bringing within its scope the working of distant locations, such as junctions, situated at a certain distance from a station. This type of remote control, as Professor Dobmaier has shown in his report, involves purely the technical question how best to construct the installations and leaves quite unaffected the general methods of working the traffic adopted in that particular country, contrary to what takes place when applying such control to an entire line. Characteristic examples of this class of work are to be found in the remote control of the *Soignies* Junction in Belgium; the signal box at *Montereau* in France, with three areas remotely controlled and one working under direct control of the ordinary type; and also the group of ten junctions situated on the line circling *Bologna* in Italy.

The saving offered by this type of remote control, as reported by the various Managements are : reduction in cost of cabling, unification of control over areas of considerable size, bringing with it a reduction in operating staff and greater rapidity and flexibility in working, as a result of eliminating the various communications and the necessary initial understanding required between the various signalmen, etc.

Engineering details.

Lines or areas remotely controlled are always provided with track circuiting, or equivalent equipment, for proving whether or not the tracks are occupied and indicating the positions of the trains. Very often advantage is taken of the existence of this track circuiting to apply automatic signalling. In that case most railways control remotely the absolute stop signals which protect points and crossings; while the stop and proceed type signals function subject only to the track circuits and automatic signalling controls.

The most usual method of transmitting the remote control to the points and signals, according to the information received by the Reporters, is by D.C. impulses. In certain systems, these impulses vary in length, i.e. the codes are formed by a combination of D.C. impulses of long and short duration, on the system known as the « time code ». A few Railways use systems having impulses which differ in polarity (a combination of positive and negative impulses) and at times the number of available codes is increased by combining these differences of polarity with a varying use of the line wires. Such is the novel arrangement adopted by the S.N.C.F. which uses one or two sets or series of 3 impulses.

The systems using long and short impulses are, by their very nature, slower than those using polarised impulses, as these last can be quite short.

In spite of its slowness the time code system is that used for the majority of installations of C.T.C. in U.S.A. and other countries. It offers the advantage that two line wires suffice to control remotely all the subsidiary locations on an entire route, however long (in the United States there are sections up to 455 km [282 miles] long) and to receive back from them all proving and return indications required. When traffic is very heavy the disadvantage of the slowness of the time code system is met by storing the controls and return indications and transmitting them in a predetermined order when the line circuit is clear or, in special cases, by multiplying the number of wires and the personnel in charge of the remote control working, as is done by the S.N.C.F. on the *Blaisy-Bas—Dijon* line.

We referred above to the application of remote control to large areas in which, contrary to what happens with C.T.C., where it is a question of a length of line; it allows of extending the area of action of a signal box over isolated subsidiary locations, often arranged radially with respect to it. For installations of this class where generally the traffic is very heavy, the more rapid polarised system is preferred.

The information supplied by the Railways on engineering details shows that several systems are in use, varying as to the number of wires required, the use of relay chains or rotary selectors on the series or parallel connection of the local selecting relays, etc. The limited experience of most of the railways outside the United States does not appear as yet sufficient to arrive at general conclusions applicable to all countries as to the equipment to be recommended for each class of application.

The capacity of remote control systems is defined by the number of subsidiary locations which can be controlled and the number of return indications available for use with each such location. Another aspect of the question of capacity, which is a function of the rapidity of transmission of the codes, is the number of controls and return indications which can be transmitted in unit time.

The capacity of the systems most used in C.T.C. working is specially designed to meet the case of numerous subsidiary locations of a simple kind with few points requiring to be operated. For example, the 20 impulse system installed in Italy (F.S.) and in Spain (R.E.N.F.E.) allows of having up to 64 subsidiary locations with 4 controls and 14 return indications each; the total capacity is 256 controls and 894 return indications. The same installation could be used, even though the number of subsidiary locations were fewer; in that case more controls and return indications would be available at each one, but the overall capacity of the installation would be much diminished. If for example, there are only 4 subsidiary locations, each of them can deal with 8 controls and 18 return indications, but in all there would be only 32 controls and 72 return indications. There is therefore a noticeable reduction in the total capacity of the installation directly the conditions for which it has been designed become too greatly departed from.

There are other, more flexible systems in use, more suited to other applications of remote control, in which the number of subsidiary locations and items of equipment controlled is not limited by the general principle of the system, such as those installed in Germany (D.B.) and in France (S.N.C.F.) and Switzerland (C.F.F.), which use polarised impulses and several line wires, with very short transmission times, which can at times do away with the necessity of storing the codes.

All Railways are agreed that the maintenance of remote control installations does not differ from that of other signalling equipment and offers no special difficulty. The grouping of remote control relays in complete assemblies with plug-in type connectors facilitates their quick replacement in case of failure when they require to be sent to the workshops for repair.

* * *

PART II.

Electric working and control devices for hinged and « flexible » points and switches. Control of accidental trailing of the switch blade.

Anything relating to the question of individual lever or route setting control of points and the organisation and arrangement of signal boxes has been regarded as being outside the scope of the present question, having been dealt with already at recent sessions of the Congress.

Our enquiry has shown that there is great diversity of detail in the electric operation of points among the various Railways. Nevertheless, the arrangements adopted always conform as regards fundamental matters and questions of principle to a point of view shared by the majority of the Administrations. This arises from the fact that the safety conditions to be met are laid down by them and at times also by the Government Department having authority in such matters. This has produced a certain degree of uniformity. On the other hand, the carrying into effect of these principles is generally left to specialised engineering firms who often make use of their own patented designs.

The summaries given in Part III tend to bring together the general directing ideas derived from the work of the three reporters. For the sake of brevity, we will confine ourselves to commenting on the two following points, in which distinct different tendencies are observable.

The motors of point machines are usually worked on D.C. at voltages between 110 and 150, or exceptionally at 24 volts when there is no main supply, and at other times by single phase A.C. or 3-phase current at 50 cycles. In Austria (Ö.B.B.) and in Switzerland, single phase A.C. at 180 volts, 16 2/3 cycles is used, taken from the overhead wires on electrified lines.

The type of current used for this class of work is thus very varied. Generally speaking, it is customary to select that type of current which, while satisfying the indispensable conditions of continuity of supply, can be most economically obtained at the point of use, without requiring in the case of electrified lines, a type different from that used for traction. Sometimes, the question of standardisation of the equipment exercises a decisive effect in this, as it affects the economic aspect of the installation.

In France, on the S.N.C.F. electrified lines, the rule is always to use for the point motors a type of current different from that used for traction. Thus in the case of D.C. electric lines, 220 volt 3-phase 50 cycle motors are used, and for A.C. 50 cycle lines, either 115 or 24 volt D.C. or 2-phase A.C. 220 volt 83 cycle motors. This results in giving additional protection against any breakdown in the insulation of the circuits that may occur. However, no railway not making this distinction between the two types of current reports any incident arising therefrom.

As regards the current used for point detection circuits, the same variation is to be observed as for the motor operating circuits, but low voltage D.C. (between 8 and 60 volts) appears to be the most used.

Opinions appear to be divided as regards the use of trailable devices in connection with the electric operation of points on main running lines. It must be understood that, although operation is electric, any trailing must always be regarded as an abnormal incident and prohibited by the rules, the purpose of the trailable feature being merely to avoid damage should points be run through accidentally.

Inquiries made by the Reporters show that trailable equipment is used regularly and sometimes systematically on running lines in Germany, Austria, Belgium, Denmark, Spain, Finland, Italy, Luxemburg, Norway, Netherlands, Portugal, Sweden and Switzerland.

On the other hand, trailable points are not permitted at all on main running lines and are reserved exclusively for marshalling yard tracks and certain secondary lines in the United States (A.A.R.), France, Great Britain, India, and New Zealand.

Looking at this question from the constructional point of view, our opinion is that the reasons which tend to give preference to non-trailable equipment should prevail, on account of the greater mechanical simplicity of the apparatus and all the advantages that come from that.

On the other hand, from the traffic operating point of view, the advantages of trailability weigh most when circumstances are such that the probability of points being run through is greater in consequence of the frequency of shunting and lack of adequate signalling, often expensive, for protecting against points being taken trailing. In such circumstances, trailability reduces to a minimum the disturbance to the traffic occasioned when points are run through and does not necessitate any specially trained staff, capable of dealing with the damage arising in such a case; this is of considerable importance especially in the case of small isolated installations.

* * *

PART III.

SUMMARIES.

The following summaries may be drawn from the reports sent in, namely :

A. — Remote operation of signal boxes : technical realizations, working orders.

1. — Remote control of signalling installations is becoming more and more extended and is developing along two distinct lines : (*a*) remote control of stations, as a rule small ones, *situated along a line* (C.T.C.); (*b*) remote control of groups of points and signals in large stations, situated in areas some distance away, or of the equipment at junctions and crossings between lines, such control being effected from a neighbouring station.

2. — On *single line,* C.T.C. is being applied in order to increase the capacity and flexibility of the working on heavily trafficked routes in order to avoid having to double the line, or to effect a reduction in the staff ordinarily on duty at the stations. The value of the results obtained under both these aspects depends on the methods of working adopted in the various countries and the conditions obtaining previously on each line in question.

3. — C.T.C. is to be recommended on *double lines* when it is a question of adopting reversible working on each track in order to obtain greater traffic capacity, or to avoid having to lay down additional lines. The best results are obtained when the periods of maximum traffic load on the two tracks do not coincide and the number of cases of trains having to be put into a siding for another to pass is large on account of a number of trains following each other at differing speeds.

4. — Remote control applied to the electric operation of points and signals in the outer areas of large stations or at nearby junctions, etc., allows of extending in an economic manner the radius of action of signal boxes to cover very considerable areas.

The saving in first cost depends on the balance obtained between the reduction in the cost of cabling and that of providing the remote control equipment. This saving becomes more noticeable as the number of items of apparatus remotely controlled at each location increases and as their distance from the central controlling apparatus becomes greater.

Concentrating the remote control of the operation of points and signals in large areas allows of suppressing the large number of staff otherwise required. This gives rise to savings in staff and greater capacity and flexibility of working.

5. — Lines or areas remotely controlled are always provided with track circuiting, or equivalent apparatus, such as axle counters, to check up the occupation of the tracks and register the movements of trains.

Generally such installations are completed by having automatic signalling applied to them, taking advantage of the presence of track circuiting.

Only those signals which protect points are habitually remotely controlled as regards their absolute stop indications.

6. — The systems most generally used for remote control transmission are those employing D.C. impulses, which can differ as regards the duration of the impulses and cuttings or concerning the polarity of the impulses.

The so-called « time code » system (code of short and long impulses) is the one most used in C.T.C.

The polarized impulse systems and the induced impulse systems seem to be preferred where rapidity of transmission becomes an important factor.

7. — Safety interlocking arrangements in remotely controlled installations are habitually effected at the subsidiary lineside locations and are consequently independent of the remote control itself. In this way, any error or defect in the transmission of a control or a return indication has no effect on the safety of the working.

8. — The numerous relays used in remote control installations are of the telephone type, but an endeavour is made to improve their quality and characteristics by a finer degree of manufacture, using improved up-to-date processes and sometimes by making them larger and more robust than actual telephone relays.

9. — These installations are widely used in the United States. Nevertheless, experience gained by most of the managements concerned does not appear as yet to be sufficient by reason of the small number of installations in use and the short lengths of time they have been in service, to enable any final general conclusions to be reached as to the preference to be accorded to this or that way of carrying out a remote control system, such as the number and function of the transmitting wires required, normal condition of transmission circuit — that is whether normally energised or not — the use of relay chains or rotary selectors in parallel or in series, and the recording and storing of controls and return indications.

10. — The capacity offered by remote control systems and their flexibility from the point of view of future extensions fall to be considered under various aspects :

1) the number of subsidiary locations capable of being controlled along a length of line; 2) the number of controls and return indications available for each such subsidiary location; 3) capacity of the system and the line circuits to transmit without delays adversely affecting the flexibility of the working, the number of controls and return indications rendered necessary by the density of the traffic and characteristics of the remote control equipment itself. This last consideration is of great importance in areas where there is heavy traffic and of such a character as to indicate it as advisable to adopt quicker working systems, or systems using more wires or transmission channels.

11. — Some Railways allow for having at remotely controlled locations on heavy worked lines a local control frame or « panel » either to control local traffic operations after disconnecting the remote control, or to enable the locations to be worked locally when the remote control is out of order.

In the small stations, it is customary to be satisfied with providing for local operation of points on the ground, either electrically or manually effected according to the particular regulations in force, either by the train crews or the staff at the station.

12. — The maintenance and upkeep of remote control installations do not appear to offer any special difficulties. Failures of the equipment itself are very few, thanks to the progress made in their design and construction. The tendency is to group relays together in suitable assemblies in dust-proof cases with plug-in type connectors. This enables any assembly to be replaced by a spare one in a few seconds. The period of regular overhaul of equipment varies with the amount of work each group of apparatus is required to perform, according to the density of the traffic.

B. — Electric working and control devices for hinged and « flexible » points and switches. Control of accidental trailing of the switch blade.

Point machines.

1. — It is usual to adopt motors capable of rotating in either direction as required. Various types of mechanism are used to convert the rotary into a straight line movement; eccentrically shaped cams, spur gear, rack drives and worm and crank drives. The amount of movement, operating stroke, and force required differ, generally speaking, according to whether ordinary heeled points, marshalling yard points, or « flexible » points are concerned.

2. — *Operating current :* The current used to operate the points is that obtained in the most economic manner in the par-

ticular locality and continuity of supply must always be assured. Some of the electrified railways use any convenient kind of current for the point motors, but on the other hand, others make a practice of employing systematically a type of current distinct from that used for traction purposes.

3. — *Point detection circuits :* All types of current are accepted for use in connection with point detection, but low voltage D.C. appears to be the most frequently used. Some Railways use a type of current different from that employed for traction purposes.

Point locking and bolting.

4. — The general practice is to connect the bolting or locking mechanism of electrically worked points directly to the operating portion, thus avoiding having to have separate bolting arrangements. Opinions vary however as to the way in which such bolting should be effected. Certain Administrations provide direct locking of the point tongues to the stock rails with the aid of a point tongue bolt, functioning with the operating mechanism of the points. This bolt can be trailable or not according to the practice of the particular Administration respecting the trailability of points. Other Administrations bolt the operating rod or rods or it may be the point detector connecting rods acting with the tongues by means of kinematical devices contained in the point machine mechanism.

Point detection.

5. — The most usual practice is to prove, by means of an electrical contact maker or circuit controller placed inside the equipment :

(*a*) that the point operating rod (or the two rods where each tongue is operated separately) has completed its stroke; and (*b*) that these rods are held and bolted by some interior mechanism which is non-reversible.

For points in main running lines taken in the facing direction, most Administrations complete these arrangements by an additional equipment comprising contacts actuated directly by the tongues themselves, in order to make certain that the closed tongue is effectively in place and tight home and that the other tongue is open properly at the correct distance. These point tongue detecting contacts may be inside or outside the point machine. Certain Administrations use these additional arrangements only in the case of points taken facing at high speeds.

These types of detection are found in modern power signalling installations under the form of « positive » or « constant » detection giving permanent control over the operation of the signals.

Local operation of points.

6. — All modern electric point operating arrangements allow of effecting when desired local manual operation of points on the ground by means of either a crank handle or lever.

As a rule, putting the handle in position for manual operation interrupts the feed to the machine. During such manual operation, the detection which indicates the position of the points in the signal box and their agreement or otherwise with the control line lever there, continues to function.

7. — Some Administrations find it advantageous for traffic operating purposes to install, in certain cases, local individual operation of the points. Such local actuation requires the permission of the central controlling box or station before it can be put into operation.

Protection against irregular action of point machines.

8. — Special measures are taken to make any irregular operation of point machines practically impossible and to exclude any false detection or return indications.

The principal arrangements that may be adopted for this purpose are :

— use of wires and cables of high insulating quality answering to very strict specifications;

— frequent inspection and measurement of the insulation resistance of a circuit and use of « earth » detectors;

— suitable arrangement of the electrical connections and wiring so rendering it impossible for them to become altered or rendered defective in the course of maintenance work;

— satisfactory arrangement of all control and detection circuits in such a way as to reveal any defect in insulation that can arise and prevent any possible extraneous current from putting the point machine in motion;

— use of suitable types of current in the detection circuits according to the kind of induced current that can be met with in each case.

Accidental trailing through of points.

9. — Opinions are divided on the question of using trailable devices to prevent damage to the points themselves or to their electro-mechanical operating mechanism. Some Administrations limit their use to marshalling yard tracks and certain subsidiary ones. On the other hand, others make use of the trailability feature for electrically operated points as a general practice on main running lines, save, sometimes, in the case of points with « flexible » tongues.

Some Administrations follow a kind of middle course in this matter. On main running lines, they give preference to the non-trailable point machines, on condition that there is a proper arrangement of fixed signals to protect the points which require to be taken from the trailing direction, but where such signalling is not provided then trailable equipment is adopted, which reduces to the minimum interruptions to the traffic and does not require the presence of special staff to make good any damage, such as results from trailing through points in the wrong direction.

10. — It is the usual practice to indicate in the signal box when a pair of points becomes trailed through, whether they are actually of the trailable type or not, by means of a visual indicator, often supplemented by an audible indication. On main running lines, it is recommended to make such detection of the « positive » or « constant » type.

Certain Administrations use counters to record the number of times points are trailed.

11. — In the case of trailable equipment on main running lines the unbolting of points which are being run through is ordinarily brought about by the action of the wheel on the open tongue, the first of the two to become displaced during such movement.

In the case of points in marshalling yards and secondary lines, simpler apparatus can be used based on the use of springs.

12. — Non-trailable equipment is generally provided with some part which becomes permanently deformed or broken during trailing; this localises the action and limits the resultant damage.

SECTION IV. — General.

[385 .57]

QUESTION 7.

Modernisation of the methods to be adopted for recruiting the staff in number and qualification.

Harmonious renewal of the various ranks, indispensable reserve lists, ratio of the permanent and temporary staff.

Part played by the medical service in the recruiting,

by Frank LEMASS,

General Manager, Coras Iompair Eireann, Dublin (Ireland).

Special Reporter.

Question 7 was the subject of the 2 following reports :

Report (America (North and South), Australia (Commonwealth of), Burma, Ceylon, Denmark, Egypt, Finland, India, Indonesia, Irak, Iran, Republic of Ireland, New Zealand, Norway, Pakistan, South Africa, Sweden and the United Kingdom of Great Britain and Northern Ireland and the territories for whose international relations the United Kingdom is responsible, by Frank LEMASS. (See *Bulletins* for November 1953, p. 837, and for December 1953, p. 985.)

Report (Austria, Belgium and Colony, Bulgaria, Czechoslovakia, France and French Union, Germany, Greece, Hungary, Italy, Luxemburg, Netherlands, Poland, Portugal and Colonies, Rumania, Spain, Switzerland, Syria, Turkey and Yugoslavia), by Dr. A. HUYBERECHTS and R. BERGHMANS. (See *Bulletin* for January 1954, p. 47.)

INTRODUCTION.

As Special Reporter on Question 7, I should like, firstly, to pay a tribute to my colleagues, Dr. A. HUYBERECHTS and R. BERGHMANS of the Belgian National Railways, who were responsible for the report on the replies received from those Undertakings which are, for the sake of simplicity, classified as those of the « French speaking Countries ». I would like to express my appreciation of these gentlemen in our collaboration together when we drew up the Questionnaire on which both reports are based. In particular, I would like to place on record the help they have been to me in drawing up the summaries, by the advice and guidance which they so generously offered.

I should like also to express my thanks to those Undertakings, which replied to the somewhat detailed Questionnaire, and which must have undoubtedly meant, for each Undertaking, considerable expenditure in time and effort.

The replies received were so diverse that it is impossible to recognise any set pattern of procedure and, therefore, to draw any definite conclusions.

Most Undertakings will agree that their staffs to-day are not as balanced in age as they would like them to be. It is, of course, easy to appreciate that many circumstances arise over which the Undertakings have no control. It is necessary to mention only

such phenomena as war, economic recession and calls for drastic and immediate economies by staff reduction, to illustrate how a staff structure can be disrupted. Nor is it easy to take effective steps to rectify the damage for which these outside influences are accountable.

One cannot avoid feeling, however, that steps were taken in the interests of expediency which might, on reflection, have been modified by taking a long term view.

In spite, however, of unhappy experiences in the past, it is surprising how the various Undertakings are unable to offer any proposals for a modification of their existing methods of recruitment and training, with a view to avoiding in the future, at least to some extent, the unfortunate results of the past.

If it were possible to make such an assessment it would probably be found that in those Undertakings which, due to whatever cause, followed a policy of drastic reductions in staff with a view to effecting immediate savings — thereby producing for themselves an unbalanced staff which would only too clearly manifest its disadvantages in years to come — the gains were more than lost by the disabilities subsequently arising.

The following is a résumé of the two reports :

RÉSUMÉ.

1. — There are 4 188 000 employees covered by the report compiled from information supplied by forty-six undertakings.

Included in this figure are temporary or casual staff, which vary in ratio from 1 % in some undertakings to 71 % in others, of the total staff employed. The incidence of employment of temporary staff is highest on the Colonial Railways and this is largely due to the fact that native labour has to be utilised.

Staff requirements are based on the numbers necessary to operate and maintain the system. The staff establishment is controlled mainly by budgetary appropriations and by the frequent scrutiny of statistical data. No radical change has taken place within the past 25 years in tests for assessing staff requirements, but any alterations which may have been made were due to such factors as reduction in working hours, improvement in annual leave, mechanisation and rationalisation. In some instances, changes were necessitated for political and social reasons.

The same tests are used to determine the requirements of permanent and temporary staff. Fluctuations in traffic and seasonal work are usually the reasons for recruiting temporary employees, and the only advantage arising from the employment of such staff is an economic one. The undertakings which recruit temporary staff have no fixed ratio of temporary to permanent staff, except on the S.N.C.F., Tunisian, Madagascar and Viet-Nam Railways, where it is fixed at 10 % to 15 %; 55 %; 25 % to 50 % and 50 % respectively.

The disadvantages arising from the employment of a large content of temporary staff are :

The inferior quality of such staff and the large turnover of labour, which results in a lower standard of efficiency;

The danger of temporary staff being absorbed in the regular establishment, which may result in increasing the establishment beyond requirements;

The tendency to retain temporary staff longer than is absolutely necessary.

The majority of the undertakings do not give preference to war or civil invalids for employment.

2. — Wages grade employees and clerical workers are recruited by way of :

a) unsought applications;

b) replies to advertisements;

c) State or other employment agencies;

d) schools, technical colleges, Universities;

e) recommendations.

Some use is made of the radio and due

to an acute shortage of labour, one Colonial Railway recruits through immigration.

Most of the undertakings have a systematic plan of recruitment and this includes a timely forecast of vacancies. The completion of a detailed « Form of Application » by each candidate is desirable, because this form is the basis of essential staff records. Although most of the Railways have a systematic plan of recruitment, the process of selection varies considerably. Generally a certificate of a prescribed educational standard is required of entrants to the service, including those in the labouring grades.

On the railways in Europe, it is the normal practice to check the candidate's social background with the Police, or to obtain abstracts from Judicial files.

A minority of the railways have a job specification, but on the other hand, the majority conduct screening interviews. Psychological tests are only in their infancy, but it is felt that they could, with advantage, be applied to staff concerned with the « Safety » of the undertaking.

Recruitment which is continuous is conducted either centrally or regionally. Staffs for the lower grades are usually recruited by district officials acting for the Heads of departments, while in the case of higher graded staffs, recruitment is done by the Central Authority, such as the General Manager or Personnel and Recruitment Officers.

There is some pre-appointment training and this is given principally to staffs engaged in the operation of trains. Post-appointment training is general, but here again the emphasis is on train operating staffs. This training includes « training on the job », correspondence courses, classes and refresher courses at schools and colleges. Training with other organisations is not a universal practice, but occasionally Colonial Railways may send selected personnel to Great Britain or France.

Training on Company history, policy, etc. is apparently not regarded as important, as the majority of the railways do not resort to this practice. On appointment, practically all employees receive a copy of the rules and regulations. It is considered desirable to issue to all employees, on appointment, a booklet embodying particulars of Company history and policy, Pension and Welfare Schemes, etc.

A probationary period is general and varies from fourteen days to three years and the majority of the Railways deem it desirable to have examinations, during and on the termination of the probationary period. The methods of recruitment apply equally to temporary and permanent staff in the clerical and wages grades, but the educational standards required for temporary employees are not as high as for permanent staff. Where training is given to temporary employees, it is not so extensive or detailed.

Subject to having rendered satisfactory service, temporary employees are given prior consideration for appointment to the regular staff.

Well defined promotional arrangements exist for the wages grades up to supervisory level. The deciding factors in making promotions are efficiency and suitability. When these are equal, cognisance is taken of seniority. There is wide variation in practice in the making of promotions, but on approximately half of the undertakings the final responsibility rests with the Managements and on the remainder with Departmental Heads. Provided they satisfy the Management as to their educational standards, wages grade employees may enter the clerical grades, usually by way of a qualifying examination.

Promotional opportunities are available to the clerical staff on all railways. Vacancies in the clerical grade are brought to the notice of the staff by way of official circular and this is a very desirable practice. Vacancies are also brought to the attention of the staff through staff discussions or occasionally by way of Press notices. The factors taken into consideration in determining promotions are efficiency, suitability

and seniority — the latter being considered the least important.

The holding of qualifying examinations for promotion, either for all grades or for certain specified grades, is regarded as an essential on approximately half of the railways concerned in the report. A few undertakings conduct periodical re-examinations for its clerical workers and failure to succeed in these examinations leads to dismissal from the service — those who are successful in the examinations do not receive monetary awards. One railway has an efficiency test for junior clerks in their third or fourth year of service and failure to pass the test on a second attempt may lead to dismissal from the service.

Two railways encourage their clerical staff to improve their educational standard through attendance at courses in Universities or Technical Colleges. Those who succeed in the examinations set by these Institutions are refunded their tuition fees and also receive monetary awards.

3. — Where practicable vacancies in the administrative, technical and supervisory grades are filled from staff within the undertakings, Universities and accredited Engineering Schools are, however, availed of in the filling of certain higher grade technical and scientific posts. There is no fixed ratio of internal to external recruitment. Observation and performance are the criteria in the filling of positions from staff within the undertakings, but in some instances it is done by way of examination.

Approximately half of the undertakings have a systematic method of selection which includes a job specification. The number of railways who create or attempt to create pools of qualified persons to balance expected vacancies is small.

Vacancies are advertised either within or without the undertaking or both. Candidates from outside an undertaking are required to furnish credentials as to character and qualifications. Few railways have Interview Boards, as interviews are usually conducted by departmental Heads, assisted by Personnel Officials.

Screening tests are not general, but where they are applied, they are usually carried out by the Head of department or senior officers in order to assess the educational and technical qualifications of candidates. The great majority of the railways have not a psychological test. Where, however, this test is considered necessary, it is done by psychologists from within or outside the undertaking.

When a diploma is required, the type of degree held conditions the selection of the candidate. Some administrations avail of open competitive examinations even where the post advertised specifies the holding of a diploma or degree. As a rule, the examination consists of a written test and this is apparently regarded as being sufficient to assess character and intellectual aptitude. The acceptance of a diploma alone appears to be preferable because it indicates that the candidate possesses the technical or professional standard required.

As far as possible, junior administrative and technical positions are filled from within. In some cases open competitive examinations are held for the filling of these vacancies and railway personnel who sit for such examinations are given either additional marks or priority. The examination consists of written, oral and graphical tests.

Promotions are made on the basis of suitability; examinations are held in certain circumstances and these are based on general education and professional qualifications. The majority of the railways have organised Selection Boards, which submit recommendations for appointments to the General Manager, or where it is appropriate, to the Departmental Minister of State concerned. Where these Boards do not function, the interviewing and selection of candidates is usually performed by departmental Heads, who submit recommendations to the General Manager for approval.

Pre-appointment and post-appointment

training is provided for on most of the railways, and is given particularly to Supervisors, Station Masters, Goods Agents and Junior Engineers. This training may be given « on the job » or in staff training schools.

4. — Practically all the undertakings recruit and train apprentices, who are guided to all the recognised trades. Training schools exist on ten undertakings, otherwise training is mainly « on the job ».

The conditions, generally, of admission to apprenticeship are : defined age limits, reasonable standard of education and usually the passing of a medical test. As well as training « on the job » apprentices receive education at day and/or night classes.

The duration of apprenticeship varies from one to six years. Where possible, however, it is considered that the period of apprenticeship for the ordinary trades should not be less than four years. The conditions for engaging apprentices normally include a contract of service or indenture. In all cases, so far as can be ascertained, the terms of engagement include wage rates, hours of duty, annual leave, payment for overtime, etc. There should be a whole-time official appointed to deal exclusively with the selection, supervision and training of apprentices. Practically in all cases apprentices receive priority for absorption into the permanent staff on completion of apprenticeship. The training and education of apprentices should be so formulated as to mould them into good craftsmen. Training should be developed later so as to fit trainees for the filling of supervisory positions.

5. — All the railways concerned in the report require candidates for appointment to undergo a medical examination before employment. Six organisations do not require applicants for temporary employment to undergo a medical test. One undertaking, which has not got its own Medical Service, requires candidates for employment to produce satisfactory evidence of health from their own private doctors. The Medical Service is also availed of for further examination, at specific intervals, of grades concerned with safe working, e. g. trainmen, signalmen, etc., who are required to undergo a vision and colour test every three years up to middle age, when the examinations take place more frequently. Some railways insist on a complete physical examination, as well as vision and colour tests, for staffs engaged in the running of trains.

It is considered that the decision to accept or reject candidates should rest with the Management, subject, however, to report and recommendation from the Medical Authority.

Candidates for permanent appointment on all railways must undergo a medical test, which involves a detailed check and examination of heart, lungs, eyesight, hearing, colour sense and general organism.

As already stated, all the railways, with the exception of six, require applicants for temporary employment to undergo medical examination before employment. This examination, while not so detailed as that required for permanent employment is not of a cursory nature.

As far as it is practicable to do so, medical examinations are carried out at Headquarters or the larger recruiting centres. Where the employment is effected remote from Headquarters, or the larger centres, medical examination is done by part-time Medical Officers, who submit their reports to the Medical Department.

6. — Particulars of the personnel replacement rate over the last 25 years are not available. Currently, however, the rate of replacement for the wages grade varies from 1 % to 30 % and for the rest of the staff from 1.6 % to 20 %.

Not all railways were in a position to supply particulars of the changes in establishment during the last 25 years. A perusal of the data supplied for this period, shows that in Europe, except for the Italian, Swedish and Danish Railways, the numbers of personnel have decreased,

whereas in Africa the numbers have increased considerably. This increase, no doubt, is due to the amalgamation of the various undertakings, which now form the existing administrations and the extension and development of the systems.

The obligatory retiring age varies from 45 years, with 20 years' service, up to 70 years of age or over — presumably as long as the employee is physically capable of performing his duties. On the other hand, retirement by request varies from 15 years' service up to 65 years of age.

The retiring age for those rendered prematurely unfit for work is not uniform on all undertakings, but it would appear that 50 years of age is the most representative.

All the railways were not able to supply charts giving details of age groups of employees, but 25 undertakings submitted details in one form or another. An analysis of the information furnished shows that the heaviest content of labour is in the age group 30 to 40 — when it decreases, but rises sharply again in the age group 51 to 55. It is also interesting to note that the content of labour in the age group 21 to 25 is relatively very low and this would appear to indicate that on many undertakings there has been a complete or partial cessation of recruitment. No doubt, the disturbed conditions which have prevailed following the world war have been to a great extent responsible for this state of affairs.

At some time or other during the past 25 years, recruitment of staff was suspended. The chief reason for this was the depression which existed in the early thirties, followed by the outbreak of the world war. Inconveniences have resulted by reason of this policy of non-recruitment in so far as the normal promotional arrangements were interrupted and as well, it created a shortage of trained and experienced personnel for the filling of higher graded posts.

A minority of the undertakings interview staff who intimate their intention of resigning in order to ascertain their reason for doing so.

From the replies received, it is obvious that sufficient attention is not given to the problem of the labour turnover, with a view to ensuring that it is kept as low as possible. It is felt that a high labour turnover can only lead to impaired efficiency and economic loss and for these reasons, it is considered desirable that the labour turnover should be frequently examined.

Only three administrations have planned to revise their present method of recruiting new staff; the remainder appear to be satisfied that their present methods are adequate and effective.

* * *

SUMMARIES.

It is surprising that so few undertakings contemplate making any change in their present method of assessing personnel requirements or are considering any plan which might produce for them a better balanced staff and a satisfactory method of renewing staff in the administrative, technical and supervisory grades.

Whilst the present unsatisfactory position in which most undertakings now find themselves in relation to their staffs can be attributed largely to influences beyond their control, nevertheless, it is considered that greater attention should be given to this question in order to alleviate the serious consequences which might arise. This would entail forecasting the position many years ahead and taking steps which would have regard not only to the needs of the immediate situation but also of the future. The following *summaries* are advanced :

1). — It is essential to establish a long term plan to ensure in a suitable and harmonious manner the recruitment of administrative, technical and supervisory staffs. This plan must meet any new situations resulting from progress in working methods (modernisation, rationalisation, etc.) and changes in social conditions, and be so conceived that it will not cause any lack of balance in the constitution of the various ranks of permanent staffs.

2). — The objectives of the plan can be attained by regular recruitment, even in the absence of imminent vacancies, and also by the formation of a reserve pool of suitably trained persons.

3). — An establishment which includes temporary employees should have their number limited to those needed for economical working.

4). — Greater importance should be given to selection of staff in order to ensure that the best of the applicants are selected.

The character, intellect and aptitude of each applicant should receive special attention.

As far as possible temporary staff should be recruited in an identical manner to permanent staff.

5). — A proper method of selection should include the following :

(*a*) job specification — at least for technical and supervisory staff and skilled workers;

(*b*) application form;

(*c*) examination;

(*d*) interview;

(*e*) psychological examination — at least applied to staff concerned with safety on the undertaking;

(*f*) comprehensive medical examination.

6). — When there are open examinations, priority or additional marks should be given to existing personnel.

7). — It is desirable that, when possible, there should be post-appointment training of staff. If there is a probationary period such training would come at the end of that period.

Pre-appointment training is essential for operating staffs.

8). — Some encouragement should be given to the staff to attend, if possible, universities or technical schools outside working hours in suitable courses. Alternatively arrangements might be made to provide such technical training within the undertaking.

9). — Ability should be the only criterion in promotion of staff. It is only when the qualifications of candidates in this respect are equal that the senior one should be appointed.

10). — It is to be noted that while the standard of fitness required on entry into employment is very similar on most undertakings, there are wide divergencies of practice regarding periodical medical examinations of employees.

It would be advisable for the chief medical officers of the various undertakings to meet in order, if possible, to agree on practices and standards in this matter, and also to offer advice on the question of the age for retirement.

11). — Employees resigning from the service should be interviewed to ascertain reasons for leaving.

QUESTION 8.

Determination of the principles of geographical and functional organisation of a railway system. Simplification and retrenchment of the administration of railways,

by R. DUGAS,

Directeur des Études Générales de la Société Nationale des Chemins de fer français.

Special Reporter.

A. — Introduction.

Question 8 was the subject of two reports :

— Report (America (North and South), South Africa, Australia (Commonwealth), Burma, Ceylon, Denmark, Egypt, Finland, India, Indonesia, Iran, Iraq, Republic of Ireland, Norway, New Zealand, Pakistan, United Kingdom of Great Britain and Northern Ireland and the territories for whose international relations the United Kingdom is responsible, and Sweden), by Bengt ADAMSON. See *Bulletin* for September 1953, p. 573 and *Bulletin* for October 1953, p. 729).

— Report (Germany, Austria, Belgium and Colony, Bulgaria, Spain, France and the French Union, Greece, Hungary, Italy, Luxemburg, Netherlands, Poland, Portugal and Colonies, Rumania, Switzerland, Syria, Czechoslovakia, Turkey and Yugoslavia), by René DUGAS. (See *Bulletin* for December 1953, p. 949).

A detailed questionnaire was submitted to all Member Administrations of the Association. We wish to express our thanks to the Managements who have been so kind to send us all useful information for the study of the questions concerned. We wish also to thank Mr. Bengt ADAMSON for his report and the personal summaries he has drafted.

B. — General matters.

We feel it will be useful to restate the general principles of organisation which Mr. ADAMSON has most wisely set out in his report and which may be considered as basic :

a) The various tasks to be performed shall be established and divided up horizontally in a suitable way among different organs and persons;

b) Efficient co-ordination at each level must be established and must be made effective;

c) The responsibility and authority shall be divided up vertically in a suitable way, in order that one will always be appropriate to the other;

d) The organization must allow for efficient control from top to bottom of the undertaking;

e) Any person to whom one or more matters are entrusted must have sole responsibility for ensuring that all the relevant duties are carried out;

f) If a person is made responsible for a function or duty, he must also be invested with the appropriate powers;

g) The number of sections set up as the framework of the organization must be the

smallest that is consistent with a sound organization; the number of direct subordinates to any one Officer must be limited to a number which can be effectively controlled;

h) A clear distinction must be made between the different sections of the hierarchy of which the organization consists, that is, Administration, Management and Executive Departments;

i) The principle of separating the consideration of policy and its execution must be pressed as far as possible;

j) Overlapping of functions should be avoided, but closely connected activities should always be grouped under one and the same management.

These principles unquestionably apply to railway systems.

Since their soundness is universally recognized, one might imagine that, when applied, they would lead different systems to adopt a standard form of organization, or at least, a very small number of standard forms of organization. In practice this is not so : the organization of Railway Administrations differs extensively between one system and another. In every country, it is the product, not only of the character and the size of the undertaking, but also of very diverse influences — legislation, historical or political events, the nature of the traffic carried, the geography of the country and the attitude of the staff, etc.

It is always appropriate, in the case of a Railway Administration, to distinguish four levels, corresponding to four general functions which can be clearly distinguished; these are :

— The « ownership » level, whose general function is the supreme control of the undertaking;

— The « administrative » level, whose duty is to determine the general policy and the plan of work of the system as a whole;

— The « management » level, which is charged with the running of the system and with putting into operation a detailed programme, within the framework of the general policy and overall plans laid down at the « administrative » level;

— The « executive » level, whose duty it is to put into effect the programme worked out by the « management ».

* * *

I.

FUNCTIONAL ORGANIZATION.

A. — The systems' top level Administration.

Railway Administrations can be grouped according to their legal form, in four main categories :

1. State railways, some of which may take the form of State Administrations which enjoy administrative independence.

2. Partially state-owned companies, the greater part of whose capital is in the hands of the State.

3. Railways which constitute Limited Companies and are corporate bodies.

4. Private railways.

The « ownership » level is made up as follows :

— In the railways referred to in 1., it is the Highest Administrative Body in the State (the Government, the Ministers, Government High Commissioners, Comptrollers, etc.);

— In the railways referred to in 2. and 3., it is the same as in the preceding case, with the addition of the General Body of Shareholders, in which the State frequently occupies a predominant position;

— In the railways referred to in 4., it is the General Body of Individual Shareholders.

The « administrative » level is fulfilled :

1) in the case of State Railways :

a) in some cases by a Ministerial Department, or by a High Official reporting to a

Ministerial Department; these may or may not be assisted by an Advisory Committee;

b) in the majority of cases, by an Administrative Board (or High Commission), which consists mainly or entirely of appointees of the State and may or may not be assisted by an Advisory Committee.

2) in the case of partially State owned companies, by an Administrative Board on which the State controls the majority of the votes;

3) in the case of Limited Companies, by an Administrative Board, on which the State is represented.

4) in the case of Private Companies, by an Administrative Board elected by the individual shareholders.

As examples of these different types we will quote the following :

— Type 1*a* with Advisory Committee : East Africa, Italy (F.S.), Sweden;

— Type 1*a* without Advisory Committee : Austria, Indonesia, Norway;

— Type 1*b* without Advisory Committee : Western Germany, Egypt, Spain, Great Britain (B. R.), Rhodesia, Switzerland C.F.F.);

— Type 1*b* with Advisory Committee : Algeria;

— Type 2 : Belgium, France ;

— Type 3 : Netherlands, Portugal, Switzerland (B.L.S. and Rh.B.);

— Type 4 : United States (Atchison, Topeka and Santa Fe, Atlantic Coast Line, New York Central, Pennsylvania Railroad), Italy (Nord Milano).

The two reports, which have been compiled, provide detailed information on the organization of the top management of each of the systems examined. In doing so, they show how frequently these organizations differ materially from one system to another. Not only do the general outlines of the organizations differ, despite the resemblances which might be inferred from the provisional classification which has been set out above; but even within a single category, important variations become apparent. For example, so far as the Administrative Boards are concerned, such vatiations are found in the make-up of the Boards, in the titles of their members, in the presence on them of transport users' and trade union representatives, in the power of a Government Commissioner or the Head of a Finance Committee to intervene, in responsibilities and powers, in the restriction of powers on matters falling within the jurisdiction of the Government and in the extent to which powers are delegated to a Managing Committee, to a Chairman or to officials.

B. — General Management.

In most Railway Administrations, management and the responsibility for operation lies with a General Manager.

In a limited number of Administrations there is a Managing Committee, consisting of high officials, with one of their number in the chair. Collectively, they fulfil the role which in other Administrations is fulfilled by a single General Manager. This applies to :

— the German Federal Railways (4 members of equal status, appointed by the Minister of Transport, with the agreement of the Administrative Board);

— the Atchison, Topeka and Santa Fe (8 members, including the Company Chairman ex officio appointed by the Administrative Board);

— the Indian Railways (a Chairman, Secretary of State and 3 specialist members for staff, movement and works);

— the Dutch Railways (a Chairman and a maximum of three General Managers appointed by the Shareholders' General Meeting);

— the Rhodesian Railways (a maximum of six and a minimum of five members, appointed by the High Authority);

— the Swiss Federal Railways (a Chairman and two General Managers).

Decisions are taken by majority vote. The Chairman has a casting vote.

It should be noted that on British Railways the lines were managed until recently by a Managing Committee, — the « Railway Executive », which consisted of 7 members (including the Chairman); this is still the case on London Transport, which is run by an « Executive » consisting of 5 members (including the Chairman). The recent abolition of the « Railway Executive » is a basic change of the very greatest importance and Railway Administrations will watch developments with the very greatest interest. Since this measure of decentralization and reduction in the number of administrative bodies of the system is still in a stage of transition, it would be premature to try to derive from it, at present, any lesson of general application.

The General Manager or the Managing Committee carries out the management of the system under the direct authority and control of the system's « administrative » body.

The reports that have been prepared show that the powers of the General Manager or the Managing Committee differ greatly in extent, according to the system. These powers are derived from one or more of the following sources — the delegation of powers made by the system's « administrative » body, statutory edicts, or standing orders approved by the Administrative Board (or corresponding High Commission).

In almost every system which is managed by a General Manager, the latter is assisted by Assistant General Managers and sometimes by a General Secretary.

The number of Assistant General Managers varies from one to five according to the system; when there are several Assistant General Managers, their functions are generally specialized.

In a fairly small number of cases, other high officials assist the General Manager and the Assistant General Managers.

It should also be noted that sometimes the General Secretary, for some or all of his functions, reports directly to the Chairman of the Administrative Board or to the Administrative Board itself and not to the General Manager. This applies particularly to matters of finance.

In some systems, the General Secretary is assisted by Assistant General Secretaries (never more than two in number). As a general rule, a Managing Committee is not assisted by a General Secretary. The Swiss Federal Railways are, at present, the only exception to this rule.

C. — Central Executive Body.

In all systems above a certain level of importance, the General Management consists of, or is assisted by, departments which help it to carry out its duties and which, with it, form the central executive body. Research, executive and supervisory departments also report sometimes to the General Management.

So far as the general arrangements and the powers of the Central Departmental Chiefs are concerned, it seems that two main types can be distinguished :

1. These Departments may act as the General Management or Managing Committee's general staff. In this case, orders are promulgated by the General Management or Managing Committee. However, the interpretation of such orders, information and requests for information may be sent out direct. In some matters, powers may be delegated to Departmental Heads to act on the General Management's behalf. The Departmental Heads may be lower in rank than the Regional Heads.

2. The Departments (or some of them) may be intermediate bodies between the General Management and the regional bodies. The Departmental Heads have well defined powers and, within the limits of these powers, they give orders directly to the regional bodies. In this type, the Departmental Chiefs must be of at least equal rank to the Regional Chiefs.

In practice, it proves to be awkward to apply such a classification to the case of a particular system. None the less, one may say, by way of example, that the following systems belong broadly to Class 1 : German Federal Railways, Greek Railways, Indonesian State Railways, Norwegian State Railways, Swiss Federal Railways, the French West African Railway Administration, Rhodesian Railways, French Railways, Swedish State Railways. The following systems belong broadly to Class 2 : Algerian Railways, Austrian Railways, American systems (quoted in the report), Belgian systems (S.N.C.B. and S.N.C.V.), Italian State Railways, East African Railways and Harbours, Finnish Railways, Portuguese Railways.

We must hasten to add that the difference between these methods of operation is less extensive than appears at first sight. In fact, though the Departmental Heads may have less extensive powers in the first case, the more extensive the powers delegated to Departmental Heads, the more closely one approaches the second case.

So far as concerns the nature of the central executive body, the allocation of services between the Central Departments is not made in a uniform manner in the different Administrations. The number of Central Departments varies according to the way these functions are grouped. However, the detailed information provided by the reports enables one to assert that, apart from a few exceptions, services are welded into a number of groups in such a way that the number of Heads directly responsible to the General Manager is not more than 10, that is, excluding executive, research and supervisory bodies, which come under the direct control of the General Management. It is to be remarked that, where there are several Assistant General Managers, each of them co-ordinates the activities of several Central Departments. This reduces the inconvenience which may result from having a number of Departments, particularly when this number is large.

Without going into the detailed grouping of services in the Central Departments, we may mention certain individual cases which are important in this respect :

— In American systems, the technical services, generally speaking, form a part of the Operating Department. It should be noted, in this connection, that certain words which are used collectively for several services, have distinctly different meanings in different countries. The differences between American terminology and English terminology have been very clearly explained by Mr. Adamson in a table to be found at the end of his report. This table also gives the meaning of the English term « Operation » which includes at one and the same time the ideas of « Exploitation Mouvement » and « Mouvement Traction », which are used on the continent of Europe;

— In Germany, it is the Commercial and not the Operating Department which includes amongst its functions those of handling, and carriage of passengers and freight and forwarding of wagons;

— The Supplies service is often linked to Rolling Stock and Motive Power; Electrification and the Electrical Department are often linked to Civil Engineering;

— In France, there is a General Research Directorate and on British and American Railways there is a Public Relations Department;

— On the Swedish Railways the basic principles concerning charges and the general programme of carriage are the responsibility of the Financial Department;

— In France the Financial Departments are responsible to the General Secretary under the direct authority of the Chairman of the Administrative Board.

Each of these subjects would be worthy of detailed examination by each system. Only the undertaking concerned can judge between types of organization or even decide on the detailed organizational provisions which are most appropriate to its own particular case. The variety of types which have been recorded is a practical confirmation of the fact that in this matter

there can be no question of suggesting a standard form of organization or even a limited number of forms of organization.

D. — Intermediate Executive Bodies between the Central Administration of the system and the local units.

The number of these intermediate bodies varies between the different systems and sometimes even between departments within a single system. Their nomenclature is also different in the various countries and this can lead to confusion through the use of terms such as « Management » and « District », which do not apply to executive bodies at the same level in the chain of command in the various Administrations.

Within the limitations of this summary, it is not possible either to list these bodies for each Administration or to describe the grouping of services at the various levels of organization.

However, it is apparent from the reports that the number of intermediate supervisory bodies is not often greater than two. Sometimes, in small systems, there is only one. The first supervisory body directly responsible to headquarters is called, in different countries : Regional Management (Western Germany, French West Africa, France, Austria, etc.), Group (Belgium), Zone (Spain), District (Switzerland), etc. The supervisory body which is second in line of command is called « Section » in some cases, and « Inspection Area » or « District » in others.

The grouping and the separation of services at the regional level may be the product either of a « functional organization » or a « geographical organization ». We will examine these types in turn and then consider variations upon them :

Type 1a. — In the case of functional organization, each of the main activities is the responsibility of a department in contact both with headquarters and with the bodies that are subordinate to it. Specialist departments exist in each geographical division.

Type 1b (variant). — Sometimes, at the regional level there is an Officer whose duty it is to guide and co-ordinate all Departments in all matters where the territorial divisions cover the same area. Despite this fact, the regional Departmental Chief Officers are directly responsible to the corresponding Headquarters Departmental Chief Officers.

Type 2. — In what is called a geographical organization all the main railway activities are centralized in each regional area. Responsibility for the whole rests on a single man (the Chief Regional Officer), who is assisted by specialist officers. In this case, within the geographical area, the different activities may be grouped either in about the same way (Type 2*a*) or in a different way (Type 2*b*) from that of the Central Departments.

On this basis one may hazard the following classification :

— Type 1*a* : East Africa, Egypt, United States (New York Central), Finland, Portugal, Rhodesia;

Type 1*b* : Great Britain (B.R) ([1]), Belgium, Italy (F.S.);

— Type 2*a* : French West Africa, Germany, Greece;

— Type 2*b* : Austria, Spain, France, Netherlands, Switzerland;

— Type 2*c* : Denmark, Indonesia, United State (Atlantic Coast Lines, Southern Railway System, Pennsylvania Railroad, Atchison, Topeka and Santa Fe), Norway and Sweden.

On the subject of the detailed grouping of activities at regional level, we will confine ourselves to indicating certain funda-

([1]) The arrangement in force at the time of preparation of the reports, which requires to be altered as a result of the recent abolition of the « Railway Executive ».

mental differences which affect the essential services :

— the « Operating » and « Commercial » departments may be grouped together or divided up in various ways;

— the activity of « Provision of locomotives and motive power staff » may be the responsibility either of the Motive Power and Rolling Stock Department or the Operating Department;

— the « Structures », « Signalling » and « Telecommunications » services may be either grouped together or separated;

— workshops may be the responsibility either of Headquarters or of the regional body.

So far as those supervisory bodies which are subordinate to the higher regional bodies are concerned, it should be noted that their organization is generally related to a departmental organization and that these departments are generally Operating (Movement and Commercial) : Permanent Way and Works, Rolling Stock and Motive Power.

In the case of « geographical » organizations, the responsibility for co-ordination lies, generally speaking, with various bodies which may even be at quite a low level. In a « functional » organization, this responsibility rests at a high level. Thus fonctional organization is natural in a small system which does not boast of any highly developed process of co-ordination, as well as at the lower levels of large systems.

We may add besides that type 1*b* has a serious disadvantage : a regional departmental head is saddled with a dual responsibility — to the departmental head at headquarters on the one hand, and to the Regional Manager on the other.

We shall return to this basic issue of the choice between functional and geographical organisation in Chapter III.

* * *

II.

GEOGRAPHICAL ORGANIZATION.

Railway undertakings which are small in extent can be operated as a single unit. In the case of systems of greater extent, the area must be geographically divided in order to keep the administrative areas to a size which is compatible in practice with effective supervision. But in the area of a single region, one finds a single department which undertakes all railway activities in the case of a « geographical organization » and several parallel specialized departments in the case of a « functional organization ».

Applying the term « region » to the body directly subordinate to headquarters, the information on the number and average size of regions in different undertakings shows that the average extent and the average number of staff of each region differ considerably from system to system. It also demonstrates that, on a single system, the importance and extent of the regions may vary widely from one region to another. A systematic examination of the information has not led to the discovery of a constant relationship or even a relationship which varies only within narrow limits between the extent of the regions and the volume of traffic carried. We may note that when the organization is wholly or partly of the functional type the variations recorded are perhaps even greater than in the case of a geographical organization.

These remarks are fully applicable to the supervisory bodies below regional level.

In explaining this diversity, it is useful to recall that the boundaries of geographical areas are often fixed on the basis of a number of different considerations — the geographical and economic characteristics of the country, the position of the main industrial centres and the distances between them, the political character of the country, historical factors connected with the development of the old systems, the amalgamation of systems, the pattern of the railway system, the existence of important railway centres, the distribution of traffic flows,

local operating problems, the development of telecommunications, etc.

In practice, two main types of division into geographical regions may be distinguished :

1. A geographical division which follows the main radial lines leading away from the town where the Headquarters Departments are located;

2. The regional headquarters are located at towns which are important either from a railway, an economic or administrative point of view. The boundaries of the regions follow from this arrangement.

The position of the boundaries of the regions and the situation of their headquarters have to meet the following requirements :

a) they must make effective supervision of the whole of each region possible;

b) they must reduce to a minimum the amount of co-ordination between neighbouring regions, to facilitate the conduct of operations close to their common boundary;

c) they must allow for convenient contact between each regional headquarters and the Headquarters of the Administration;

d) they must make for easy contact, at each regional headquarters between the railway management on the one hand and the users and the regional authorities on the other.

Solution 1) seems the better so far as point *b*) is concerned. Co-ordination between neighbouring regions is, in practice, at a minimum along the main arteries which serve the regional boundaries. It is also made easier in the area near the centre, where the interregional railway connections with the densest traffic flows are generally situated; in addition the concentration of the regional headquarters and the central headquarters in the same place fulfils completely condition *c*). On the other hand, the regional headquarters is displaced from the centre of the region, considered as a unit, and, indeed, is often placed on its edge. This is an unfortunate factor so far as points *a*) and *d*) are concerned, where the contact with important provincial centres is involved.

Solution 2) presupposes a certain uniformity of technical standards and operating methods throughout the system as a whole. This solution seems to be satisfactory so far as points *a*) and *d*) are concerned. On the other hand, it produces problems of co-ordination between regions over the running of interregional trains. It has the associated disadvantage that certain regional headquarters are situated too far from the central headquarters.

* * *

III.

DISCUSSION ON THE CHOICE BETWEEN « FUNCTIONAL ORGANIZATION » AND « GEOGRAPHICAL ORGANIZATION ».

In order to provoke discussion on this problem the questionnaire which was sent out to Undertakings included the following questions :

« What are the advantages and disadvantages of an organisation in which all the responsibility falls upon a single officer in a given territorial zone ? »

« What are the advantages and disadvantages of an organisation in which all the responsibility, in a given zone, falls upon different officials according to the Department ? »

In practice, this choice is one of the most, if not the most, important of the basic decisions which Railway Administrations have to take on the subject of organization.

The Administrations have expressed widely divergent opinions on this subject. Their replies may be grouped as follows :

A. — Geographical organization.

a) Advantages.

1. It ensures that decisions taken by the regional supervisory body in question are

taken rapidly and are fully consistent one with another. It also ensures that matters affecting the various departments are quickly co-ordinated. All this of course assumes that the responsibilities entrusted and the authority delegated to the chief regional officer are proportionate one to another. This officer's special concern is to watch over all the sections concerned; he must not favour one branch of the service to the detriment of the others in the decisions that he takes. He must do more than simply co-ordinate; he must reconcile the activities of the different branches. At the same time, it is as well to ensure that specialization is not neglected in the decisions that are taken. To this end, the official in charge must have every opportunity to consult with the specialist services.

2. It allows the executive process to be decentralized. The lower levels are left scope for initiative and the extent of their power of command is greater.

3. It allows for better control and closer supervision of the outdoor staff through more direct contact with the staff. This makes it easier to maintain discipline.

4. Transport users and public authorities are confronted with Chief Regional Officers whose authority covers all the principal activities.

b) Disadvantages.

1. The individual manager may be overtaxed.

2. It is difficult to find sufficient Chief Officers who command, in adequate measure, the wide experience and the great ability which fit an officer to put into effect the general policy laid down by the General Management and its assistants at headquarters, in all aspects of railway work.

3. It is necessary, in the end, to reduce the size of the regional areas. Otherwise specialist assistants will have to be appointed to help the individual manager.

4. There is a danger that, despite close co-ordination between regions, the orders given by headquarters may come to be put into effect in different ways by the various chief regional officers. This danger has led the S.N.C.B. to abandon the experiment in geographical organization (« Groupes » in Belgium), which was made from 1942 to 1947. The disadvantage became apparent when it hindered the standardization and rationalisation of methods of work.

5. It is necessary to provide the same number of bodies at each level in each department. As a result, certain departments must have a larger number of sections and a larger staff than in a departmental organization.

B. — Functional organization.

a) Advantages.

1. Thanks to specialization, the work is better divided and the operations connected with the different departments are better performed. Efforts can be concentrated on a single phase of work without any interference. There are widespread opportunities for adaptation. There are opportunities for the exercise of initiative when there is no single all-powerful officer in authority.

2. Each Department can be given the form of organization most appropriate to it.

3. Similar operation can be carried out in the same way throughout the area served. Instructions given by headquarters can be easily comprehended and quickly put into effect.

4. Headquarters are better informed on how the execution of policy is proceeding. As a result, they are able to issue effective orders and directions with full knowledge of the background.

b) Disadvantages.

1. There is a danger that specialization, when pushed too far, may cause the general picture of operations and the interests of

the system as a whole to be lost sight of. As a result provision must be made for very close co-ordination between departments. The need to take co-ordinating measures of this sort has led the Administration of the Netherlands Railways to amalgamate in a single Operating Department the local Inspectorates which were attached to the Movement, Permanent Way and Works, and Motive Power and Signalling Departments.

2. It is difficult to take decisions on important matters when the departmental heads hold different opinions and their areas of authority overlap.

3. The execution of the policy decided upon by the central management is not uniform throughout the area served by the system.

4. The organization with which transport users and public authorities have to deal is complicated by the fact that there are different regional officials for the various matters to be dealt with.

5. Control over the executive branches is looser. Associated with this there is a danger that certain functions may be inadequately performed.

* * *

IV.

ADMINISTRATIVE STAFF ESTABLISHMENT.

Administrations were asked for statistical information, with the object of finding out the systems' administrative staff establishment at headquarters and in the other supervisory bodies considered together.

It is possible to work out from the replies that have been received the percentage relationship of this establishment when compared with the total establishment of the system. But, of course, there is no question of making straightforward comparisons between the figures worked out in this way for the following reasons :

— It is very often difficult to establish a clear distinction between administrative staff and other staff. There is a considerable element of approximation in this.

— Certain research, inspection and even executive departments sometimes form an integral part of the supervisory bodies and are sometimes separated from them. Accordingly, some Administrations have included the corresponding establishments in their figures for administrative staff, and some have not.

— The replies are not entirely the same in respect of the period selected. In principle, this was the calendar year 1951 and certain of the replies have had to be supplemented.

— Finally, the extent and the importance of the system has a considerable influence on this percentage.

With these reservations, the results of the calculation lead to the following conclusions :

On the main European systems, the normal percentage of the total administrative establishment in the supervisory bodies when compared with the total establishment of the system runs to between 6 % and 10 %. On the less important European systems, it is between 10 % and 15 %. On American systems, the average percentage is as much as 20 %. This last can be explained by the fact that, on the technical side, rationalization is well advanced and by the fact that, thanks to the systems' financial resources, it is possible to exceed the minimum number of essential administrative staff with the object of increasing the rate of progress both in the technical field and in organization.

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V.

SIMPLIFICATION AND CONCENTRATION OF RAILWAY ADMINISTRATION.

The object of all research and study of the subject of railway organization is to enable railway administration to be sim-

plified and concentrated. The replies received show that this is a subject of constant and serious concern to Administrations. The measures taken in this connection may be summarised under certain main headings :

a) Centralization of work :

Centralization of work done in various places increases the efficiency of operation by means of thorough specialization. It increases productivity as a whole by relieving some of the staff who were responsible for this work of the specialized activities. In particular centralization of this kind can be justified in the fields of accounting, duplicating, statistics, audit, payment of pensions, purchasing, printing and safety departments.

b) Amalgamation or regrouping of activities :

This step generally enables a reduction of staff to be made. There are many examples of this. We may mention :

In French West Africa, the amalgamation, at regional and district levels, of the secretariats and staff offices; in Germany, the amalgamation of the Central Movement offices and of Technical offices and the amalgamation of the Traffic Departments and important stations; in Belgium (S.N.C.V.), the abolition, amalgamation and regrouping of departments at a local level (depots, workshops, laboratories, research departments and regional accounts offices); in France, the amalgamation of subdivisions within the regional departments and a corresponding abolition of Divisions in these departments, and the amalgamation of audit offices where District headquarters are in the same place; in Italy, the amalgamation of Accounts Inspectorates and Cashier's Checking Sections; in Finland, proposals for extensive administrative reorganization by which it is planned, in particular, to regroup eight central departments into four departments; in Norway, the amalgamation of the Traffic and Operating Departments is being considered; in Sweden, the amalgamation of the passenger operating and freight operating departments and also the passenger commercial and freight commercial departments.

c) Revision of the geographical extent of certain supervisory bodies' juridiction :

This change is the result of abolishing certain geographical units. There are numerous examples of this also :

In Germany, the abolition of small units of management and the division of their functions between the neighbouring units, the reduction of the number of depots and Permanent Way districts; in Austria, the reduction of the number of sections, the abolition of departments and re-allocation of their work within the managements; in Belgium (S.N.C.B. and S.N.C.V.) the abolition of regional groups; in France, the abolition and amalgamation of districts; in the United States (Pennsylvania Railroad) wholesale abolition of geographical divisions; in Finland, the abolition of sections; in Sweden, the reduction of the number of districts and the number of sections.

d) Elimination of intermediate bodies :

This operation, by its very nature, brings about reductions in staff. We have already mentioned the example of the Pennsylvania Railroad which has amalgamated divisions by eliminating the « Superintendent's Divisions ». The following cases may also be quoted :

In Great Britain (London Transport), the abolition of divisions and direct linking of the subordinate districts with the Operating Manager; in French West Africa, the elimination of the section level in the Permanent Way Department; in Norway, a plan for getting rid of district officers as intermediaries between the central departments and the workshop managers; in Sweden, the same operation as in Norway so far as workshops and stores are concerned and in addition, a plan for eliminating the Sections, which are subordinate to the Districts.

e) Inauguration of sections responsible for special duties :

The setting up of special sections gives rise at first to an increase in staff, but its consequences very often lead in the end to a reduction. We will mention the following examples :

In Austria, the inauguration of Central Offices with a view to centralizing administrative work; in Belgium (S.N.C.V.) the institution of new centralized services (aptitude testing, safety, organization); in Spain, the launching of an economic control organization, responsible to the general management; in France, the setting up of an expenditure control system; in the Netherlands, the setting up of the Operating Department already mentioned; in Italy, the division of the Works and Building Department into a Works Department and an Electrical Equipment and Signalling Department. This follows the development of electro-mechanical equipment.

It is of interest to note that no system has reported the abolition of any sections responsible for special duties.

f) Decentralization of authority and powers :

Each system tends to effect as extensive a decentralization of powers as possible, in those fields in which centralization is not made imperative by the nature of the work. A decrease in size of headquarters offices is always of major interest. Since the measures taken in this respect are designed for the particular needs of each system, a detailed account of them would not be of general interest. They touch upon almost every branch of railway work.

g) Simplification of administrative methods of work and elimination of administrative procedures :

Every Administration pays attention to its administrative procedure with the object of simplifying it at every level. We may mention by way of example : the fixing of levels of establishment for sections of administrative staff, the setting up of a procedure by which operating and works programmes are drawn up, the improvement of budgetary control, the extension of typewriting, printing and duplicating, the reduction of administrative work at unimportant stations by concentrating it at more important stations, the elimination of unproductive work, particularly in respect of statistics and printed matter. We may also mention the production of a booklet designed to instruct technical staff who are undertaking administrative duties for the first time and also one administration's plans to reduce the number of grades of staff so as to leave only those which are essential to the chain of command.

Finally, we would recall those measures of rationalization which are bound up with investment and which bring about reductions in staff. Such measures include the extension of electrification, the concentration of forwarding of freight, the setting up of railheads and the simplification of operating methods on branch lines.

From the account given above we draw the following summaries.

SUMMARIES.

I. — Functional organization.

1. — The principles and particularities of functional organization on different systems vary considerably as between the different Railway Administrations.

2. — It does not seem to be possible to make an *a priori* decision, based on broad generally recognized principles of organization, that one fully elaborated type of organization for the whole of a particular system whatever that system may be, is to be preferred to all others. Only by detailed analysis of the application of these principles in each particular case can an opinion be given on the general solution which seems to be most suitable.

3. — It also seems impossible to deduce, by means of a methodical analysis of the various forms of organization adopted by

the various systems, that one form of organization is always and incontestibly preferable to every other form.

Every form of organization which has in fact been adopted by a Railway Administration has advantages and disadvantages. The fact that a form of organization proves satisfactory to a particular administration cannot be taken to imply that it can be recommended to another administration; the advantages and disadvantages must be weighed in each particular case.

4. — Because it is impossible to refer cases to a single standard type or organization or even to a limited number of standard types of organization, a critical examination of a system's organization can only usefully be conducted by considering separately each group of activities for which there is only a small number of possible solutions in existence.

The observations set out above under points 2 and 3 on the subject of the overall organization of a system, apply equally well to detailed organization.

5. — It is useful to distinguish in a Railway Administration four levels corresponding to four general forms of activity. These are :

— the « ownership » level to which the general control of the undertaking belongs;

— the « administrative » level whose duty it is to determine general policy and the system's overall programme of work;

— the « management » level which is entrusted with the running of the system and the detailed working out of the programme, within the framework of the general instructions received from the level previously mentioned;

— the « executive » level whose duty it is to carry out this programme.

It is desirable that the four general functions mentioned above should be clearly defined and precisely allocated.

6. — Apart from matters within the province of the Higher Administration and, ultimately, the Shareholders' General Meeting, the decisions on the organization of a system which, it appears, have to be considered the most carefully, are concerned with the following questions :

— at « administrative » level :

The determination of the powers to be delegated to the General Manager (or to the Managing Committee);

— at « management » level :

Whether to integrate the Headquarters Departments within the General Management or to make them into an additional supervisory body;

The grouping of activities at headquarters level, the number of chief officers to report to the General Manager (or Managing Committee) and, when occasion arises, the co-ordination of Departments by the Assistant General Managers and the separation of the essential activities on the one hand and the sections concerned with special centralized work on the other;

— at the « executive » level :

The number of intermediate supervisory bodies between headquarters and the local units;

The choice between a « functional » form of organization and a « geographical » form of organization;

The fixing of the respective duties of the chief officers at headquarters and the chief regional officers;

The grouping of activities at each « executive » level;

The delegation of powers to be made in respect of the different levels of the organization.

II. — Geographical organization.

7. — The particular forms of geographical organization of railway systems vary to a considerable extent between the different Railway Administrations.

8. — The boundaries of every geographical area and the place chosen for its

headquarters should meet the following requirements, as far as possible :

— they should allow for effective control throughout the area in question;

— they should reduce to a minimum the amount of co-ordination required with neighbouring areas;

— they should allow for easy contact between the area headquarters and the headquarters immediately superior to it in the organization;

— they should make for easy contact between the railway management on the one hand and the Public Authorities on the other.

III. — General recommendations.

9. — So far as the geographical and functional organization of a system is concerned, a Railway Administration must make its choice between the different solutions according to its own judgment of the relative disadvantages and advantages of these solutions when applied to its own particular case.

10. — It is recommended that the following general principles be applied in respect of a system's organization :

a) The number of supervisory bodies should be as small as possible;

b) At each level of the organization, the different activities to be carried out must be clearly defined and allocated with full regard to the importance of essential activities;

c) Effective co-ordination must exist at every level of the organization;

d) Effective control of one level of the organization by the other must be set up;

e) The number of subordinates responsible to a single superior must be limited to the maximum number which is compatible with proper control;

f) Responsibility and authority must be defined at every level of the organization in such a way that the one always corresponds to the other.

11. — A system's organization must either be under continual examination or must be examined at sufficiently close intervals for it to profit from every simplification which may increase administrative efficiency without increasing general expenses and which may reduce the administrative staff establishment without impeding either the smooth operation or the improvement of the system. To this end, it is appropriate to consider such steps as :

a) Centralization of certain work;

b) Amalgamation or regrouping of activities;

c) Revision of the geographical sections into which the area is divided and the corresponding abolition of some divisions;

d) Abolition of intermediate supervisory bodies;

e) The installation or abolition of sections entrusted with special duties;

f) Decentralization of powers and of authority;

g) Improvement of administrative methods of work, with special reference, in this connection, to modern techniques and particularly to mechanization;

h) The abolition of unproductive administrative work.

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QUESTION 9.

Railway participation in road transport undertakings,

by Dr. G. DREYER,

Secrétaire Général adjoint des Chemins de fer Fédéraux suisses.

Special Reporter.

Question 9 was the subject of the two following reports :

Report (America (North and South), Australia (Commonwealth of), Burma, Ceylon, Denmark, Egypt, Finland, India, Indonesia, Irak, Iran, Republic of Ireland, Netherlands, New Zealand, Norway, Pakistan, South Africa, Sweden and the United Kingdom of Great Britain and Northern Ireland and the territories for whose international relations the United Kingdom is responsible), by Dr. J. P. B. TISSOT VAN PATOT. (See *Bulletin* for January 1954, p. 1).

Report (Austria, Belgium and Colony, Bulgaria, Czechoslovakia, France and French Union, Western Germany, Greece, Hungary, Italy, Luxemburg, Poland, Portugal and Colonies, Rumania, Spain, Switzerland, Syria, Turkey and Yugoslavia), by Dr. G. DREYER. (See *Bulletin* for February 1954, p. 239).

I.

The problem of the participation of railways in undertakings running road transport services is, as we have already reported, one special aspect of the transport policy. Its solution depends as a matter of fact to a preponderant extent on the amount of latitude left to the railway undertaking to operate passenger and freight road transport services either itself or on its behalf. In other words, it depends on the organisation of the transport industry in the different countries concerned.

The operation of road services by railway companies can be done, as the two reports show, either directly (operation « en régie » [*]) or indirectly, by making contracts with private undertakings, or finally by making use of affiliated companies (called semi-direct operation in Mr. TISSOT VAN PATOT's report).

The analysis of the replies received shows that nearly all railway administrations are able to make use of these three methods for operating road services, or at least one or other of them. This basic fact also emerges from the enquiry carried out in connection with the organisation of the transport industry by the Working Group dealing with the co-ordination of transport, on behalf of the Geneva Inland Transport Committee (see document TRANS/WP12/8 of the 20th March 1952, and addendum 2 of the 4th February 1953).

Undoubtedly, the use made of this right to resort to the road transport technique in one way or another differs from one country to another, and legislation or administrative practice has resulted in many cases in regulations which limit or restrict it.

When these restrictions are analysed, however, it is found that they derive from an empirical and ill-defined transport

(*) « En régie » has been translated in the reports by « under separate statutory organisation ».

policy, either based on considerations which are often legitimate, such as the desire to apply to the railway administrations when conceding authorisations the same regulations as those imposed on private undertakings so as not to favour the former in any way, or the wish to keep the railway strictly within its own field and avoid, for the sake of equilibrium, any straying into the field of road traffic, or the fear of seeing the railway operating road services in a less rational and less economic way than road transport undertakings, which would have the effect of still further increasing its deficits, and finally the fear that the railway would invest capital really needed for its own modernisation in road transport undertakings.

It would be easy to reply to these objections by pointing out that it is precisely those railway administrations which have made the greatest use of the road technique that have shown the most favourable financial results, and in general, this possibility has enabled them to carry out in a methodical manner the rationalisation of their operation and its adaptation to modern progress : two essential factors for any healthy undertaking. Consequently, it is necessary to examine how the use of the road technique by means of the different operating methods mentioned above can be included in a transport policy which aims at a true co-ordination of the different means of transport in the interest of the general economy as well as of its clients.

II.

The possibility of being able to make use of the road technique is considered by the railway administrations to be an essential postulate. We have already stated in our report the point of view put forward by the International Railway Union in its pamphlet, published in 1951, on the « Present situation of the European Railways ». They have continued to press this point of view. They defended it in particular on the Work Group dealing with the co-ordination of transport at Geneva (Document E/ECE/TRANS/324 of the 29th April 1952) and, more recently, in a letter addressed by the President of its Managing Committee to the Manager of the Transport Division of the Geneva Economic Commission of Europe. After reporting certain reservations noticed in various circles regarding the free choice of technique by the railway, and in particular the possibility of the railways to make a wide use of the motor, the representative of the I.R.U. (U.I.C.) went on as follows :

« On this latter point, the marked opposition of road undertakings is due to a fear of abuse by the railway which might, they say, by granting unjustified reductions in the road rates, compete unfairly with the professional transport undertakings. It seems however that any such possibility need not be feared if the use of the motor by railways was subordinated to conditions and supervision which the railways would in no way object to provided there were equitable parity as between the obligations of the Railway and the Road. Moreover, this moderate position appears to be — with some reservations it is true — that taken up by the International Chamber of Commerce on the occasion of the issue of the memorandum I.R.U.-U.I.C.-C.C.I.

» Moreover, how can it be argued that an industry has not got the right to make use in every case of the techniques dictated by modern progress ?...

» In this capital matter, opinions should indeed be reconsidered, all the more so as — under various forms, directly or indirectly — the railway is already at the present time a very large road transport undertaking. »

This, undoubtedly, is one of the most important points, as well as the most controversial point of the transport policy, and that upon which it is consequently necessary to insist. Is the railway an administration fulfilling the functions of a public utility, or is it an industrial undertaking ? During the whole period in which the railway enjoyed a monopoly of transport, a

period which, everyone knows, lasted until the first world war, and even a little after it, the first idea predominated. As the railway was not exposed to competition, a great many very heavy obligations were imposed on it, which there is no need to go into as they are well known : obligation to operate, obligation to carry, to apply standard rates, social and economic burdens, obligations regarding conditions of employment, wages and social security, including pensions, etc.

Today, now that the transport monopoly it enjoyed has disappeared, the railway is considered as an industrial undertaking and expected to run economically. The railway administrations are in complete agreement with this point of view. They themselves have asked that the public authorities should treat them as « undertakings having an industrial and commercial character », obliged « to keep themselves up-to-date, and to adapt themselves to technical progress in order to meet competition and give the service expected of them » (see Report of I.R.U. (U.I.C.) on the « Situation of the European Railways », published in February 1951, p. 26). But in this case we must be logical, the railway must be freed from certain legal obligations and unduly strict regulations, indemnified fairly for the burdens still imposed upon it, which have no part in commercial management, and given the flexibility of a real undertaking, enabling it in particular to rationalise its working by the use of the motor technique.

In the first part of his report, Mr. Tissot van Patot reported in a very remarkable way the general reasons which can lead any undertaking, that is rationally organised, to adopt a new technique, and the special reasons which have led the railway to make use of the motor technique. His well knit arguments refute in advance the objections which can be raised to this fundamental postulation of the railway. They were also brought up by the I.R.U. (U.I.C.) representatives during the discussions which took place at Geneva on this problem within the Inland Transport Committee (see in particular document TRANS/83 of the 30th November 1951).

Starting from the basic considerations we have given, namely : 1) that the railway in most cases has the legal or statutory right to make use of the road technique, though often only to a limited extent; 2) that in many countries the railway is already making use of this right and has its own road services; 3) that this right should logically be considered as one of the essential attributes of the railway if it is considered as an undertaking, so that the principle of making use of the road technique can no longer be legitimately contested. It is rather the way in which this regime will be used and the way in which it will be reconciled with the idea of a co-ordination of the methods of transport which should be gone into today, in order to establish a clearly defined doctrine, both as regards the railway undertakings and the governmental authorities in finding a solution to this infinitely complex problem of the relations between two essential techniques which between them share the whole overland transport.

III.

The quest for a solution and a doctrine must obviously start with an analysis of the present situation of overland transport from the objective angle of the needs to be satisfied and the means available, and from the subjective angle of the transport firms who have to deal with the traffic.

Considered from the objective angle of the traffic to be carried and requirements to be met, the situation differs according to whether it is question of passenger or freight transport. But in both cases, the evolution already noticed before the last war has since continued at an accelerated pace and considerable changes have taken place.

In the case of passenger transport, the serious damage the railways suffered during the war had as its first effect the development, as soon as hostilities ended, of transport by motor, in order to fill in the gaps

in rail transport. But the motor services often ran parallel to the railway line. When the latter was restored and the stock of coaches rebuilt and brought up-to-date in order to enable the traditional traffic to be met, the motor services did not wish to give this traffic up or become supplementary to the railway. As on the other hand, private motorcars were increasing in number very rapidly, the motor services were finding it necessary to keep the traffic they had acquired under these favourable circumstances. Moreover, tourist traffic was developing and taking on new forms, the people of countries which had developed economically more than in the past felt the need to travel, to get acquainted with other places and other countrysides, a need which the motor services were often better able to satisfy than the railway. Or rather, in the organisation of tourist travel, each of the two methods of transport has its own proper function and part; they combine and complete each other admirably. Their interpenetration and amalgamation is much more normal than their antagonism.

In the case of freight traffic, it is possible to draw a parallel whose broad lines are very similar to those arrived at in the case of passenger transport. Just as, for the latter, the railway and the motor suffer from the ever increasing competition of the private motor, here again both the railway and the professional freight transport firms have to fight an ever increasing battle against the competition of the private lorry. The road haulier is consequently inclined to hang on more determinedly to what traffic he has acquired. There then rises opposition between the railway and the professional haulier, whereas both of them have the same interests and are intended, more in this field perhaps than in any other, to complete each other and collaborate with each other. In effect, the perfecting of the transport technique, especially by the use of containers and rail-road trailers, by the application of the central station system, calls out for a combination of the two methods in order to obtain more rational and economic operation of the public transport services of which they are both an essential part.

Therefore the modern and rational carrying out of *public transport* involves more and more the combined efforts and collaboration of rail and road on both the technical and operating plane. To this technical necessity should correspond a similar evolution in the legal plane and commercial organisation, otherwise there is a risk of hindering the essential adaptation.

It must unfortunately be admitted that a very different development is occurring in this field. Instead of an organic coordination between the two techniques in the case of public transport, there is ever increasing opposition between the exponents of the two techniques, an opposition, and this is much more serious, which tends to pass from the commercial and technical plane to the psychological and political plane. Perhaps there is no need to seek any further the deep lying cause of the failure to which numerous attempts to regulate the relations between rail and road by legislative means have been doomed. In presence of the apparently irreducible antagonism that separates railway and motor, at times attempts have been made to establish a certain equilibrium between them, by defining and delimiting their respective fields. This was perhaps due to a failure to recognize the law of this progressive interpenetration of the two techniques in the most varied fields.

It is not forgotten that certain theories have contributed to this result and created a certain amount of confusion in peoples' minds. Such as the theory that the user should have a free choice of the method of transport which suits him best. In the case of public transport, this theory is absolutely absurd and anti-economic. The most important thing is to allow and stimulate progressive rationalisation of public transport, and not to create and maintain two parallel systems of public transport in opposition to each other.

Starting from this antagonism which was considered unavoidable, an endeavour was made to « limit the damage » by means of syndicate agreements between the railway on the one hand and professional road transport firms on the other. Characteristic examples are to be found in France, Switzerland and Italy.

It is obviously difficult, or in any case premature, to pass judgment on such agreements which, drawn up after examining a given situation, can only have a restricted scope by reason of the limited experience available, interesting, indeed, but not exhausting the problem. We can only quote what the president of I.R.U. (U.I.C.) has said about them in the letter already quoted :

« Without denying the interest of such agreements and their constructive character, one is forced to state that they are trying to solve particular cases or form provisional solutions, rather than making a contribution to the general doctrine. In addition, whatever the advantages of direct contacts between the different methods of transport... it does not appear that such problems as the co-ordination of Railway and Road can be solved, in their entirety, by a simple agreement between those concerned. Railways and public hauliers are in effect essentially different structures; the former are vast undertakings, controlled by the State, functioning under minutious controls and precise obligations, having the character of a public service, and an exceptional character of universality and permanence, whereas the latter are made up of innumerable transport undertakings, the majority of which are only small concerns, the grouping together of which on the national or international plane in order to defend their legitimate interests, is only poorly adapted to the carrying out of the obligations of a public service and the enforcement of strict discipline. In fact it is for the State to set up a regime in which two such dissimilar entities can and should exist side by side. »

IV.

What appears to be both logical and certain is that the railway's right to deal directly with hauliers or take a direct interest in road transport undertakings must be safeguarded in every case, if we are not to compromise or falsify normal evolution and sane and progressive rationalisation, at the same time as organic co-ordination of public overland transport.

The enquiries which have taken place on the different railways show the vast possibilities opened up by the working of the road technique by the railway. It also shows that in so far as the choice to be made between the different methods of operating is concerned, it is difficult to formulate any definite criteria from which to state that such and such a method is in every case better than the others. The choice of the method depends, as we have shown, on the different factors which may make one or the other to be preferred, according to circumstances. These factors may vary from country to country, according to the conditions and statutes of each administration, according to the region of the same country, and above all according to the kind of traffic to be dealt with and the problems to be solved.

For example, it is not possible to condemn the system of running their services « en régie » as being less profitable or less rational than another method. It has often worked out very well. In the case of passenger traffic, Switzerland can be quoted as an example in this connection, where two groups of transport firms, P.T.T. and the concession holders of the postal services on the one hand, and the Federal and private railways, on the other, share the responsibility of running the public services. They operate together a system of more than 12 000 km (7 450 miles) without any parallel services. On the commercial plane, coordination is perfect, and gives the ideal system for the two methods of transport. In addition, the advantages to the traveller are considerable (issue of through tickets to all places in the country, use of

common transport documents, combined rail-motor group journeys, etc.). As a public service, the Swiss system of railway lines and postal services forms a whole which meets all traffic requirements and satisfies the exigencies of rational operation. The only drawback to this solution lies in the fact that the railway has no chance to get a sufficient share of the occasional traffic. On the other hand, such a system which does not depend on common organisation but on two parallel organisations, can only work when founded, as in the case mentioned, on complete confidence and absolutely irreprochable liaisons. When such a condition is not realised — as is the case in certain countries — it is necessary to set up the organisation which will entail perfect unity of doctrine and action.

In the case of freight traffic, there is no similar organisation unfortunately either in Switzerland or anywhere else.

As for other systems of road working, we have seen that these can be divided up into two main categories : indirect working by means of contract and indirect working (or semi-direct) by means of associated companies (in which the railway holds most of the shares), or by a small share in road undertakings.

The first of these categories offers a whole scale of possibilities : hiring out vehicles, charter contracts, renting out services, commercial agreements assuring the railway of certain dues in exchange for other services or advantages. All these possibilities are now used cumulatively or alternatively by the railways and often on a very large scale.

However, the enquiries made also show very clearly that where it can be applied in a consequential fashion, the solution preferred is indirect participation (or semi-direct) by means of associated road companies. This system also has marked advantages over the various solutions of the first category. These have been listed and analysed very thoroughly by Mr. TISSOT VAN PATOT (figures 5 and 9 of his report) to which we will refer readers. Mention must however be made of certain particularly interesting aspects in the elaboration of a coherent public transport policy.

The system of operating road services by means of an associated company has the great advantage, for both the railway and the public authorities, of setting up an independent legal entity, and consequently financial autonomy.

The railway can adapt itself much better to the road technique in this way : the management and the staff are experienced in the working of a road transport undertaking, their status is different from that of the railway, and in principle like that of any other motor undertaking, the methods are different. On the other hand, coordination is complete as regards the rates, timetables, routes, traffic worked. The psychological obstacles which often hinder road operation when it is too closely bound up with railway organisation disappear. The psychological obstacles, of a different kind, which are against the collaboration between the railway and private independent undertakings also disappear. The railway administration has no more scruples in handing over to the associated company that traffic which the latter can work at lower cost. The whole public transport organisation benefits by the greater flexibility. The system of associated companies makes possible, at one and the same time, a great concentration of certain factors (purchase of vehicles, repair shops, administration, accounts) and, if necessary, thorough decentralisation. This, for example, may make it possible to divide up the system into numerous regions served by the same number of associated companies which can be connected together by a common organisation. This, in its turn, leads to a progressive rationalisation of the road transport itself, and a reduction in its costs. The system of centre-stations, which has made it possible to speed up the rationalisation of the railway by freeing it from the unprofitable services, received a new impulse from the creation of associated companies to serve them.. Finally, the formula

has commercial advantages of another kind, by enabling the associated companies themselves to share if necessary in other road undertakings leading to a still more extensive rationalisation.

All these facts, based upon experience already obtained, but unfortunately not yet sufficiently numerous, have as many advantages for the community as for their clients. The authorities do not have to worry about the railway increasing its financial troubles, nor about additional labour costs. The railway does not have to invest large sums of capital in buying vehicles or equipping garages and repair shops; it merely has to invest sufficient capital in the motor or lorry undertaking to give it the necessary influence and authority. One of the most delicate problems of coordination, that of the distribution of the traffic between one and the other of the two techniques, is solved to a great extent. The fact that like all private undertakings, the associated company has to balance its accounts is an additional guarantee for the authorities who may consider they have a right to control it. The advantages for clients are equally obvious, since they are assured of a more complete service and since the rationalisation of public transport to which the system tends must necessarily lead to a reduction in the cost. There is less risk in any case of the prices going up than when, owing to the persistence of expensive competition, the public authorities have to take steps to prevent it. In addition, the system has the advantage of giving the user a much more homogeneous and coherent commercial organisation.

V.

In enumerating the advantages of the system of participation, especially that of associated road companies, we do not wish to imply that this completely solves the problem of coordination, as it is not the only factor, but it is one of the factors which will contribute the most effectively towards its solution.

It is, on the one hand, essential that each railway administration should attach the primordial importance to this problem which it deserves, by setting up a special coordination department in the management itself or by handing this responsibility over to an associated company, as has been done in France with S.C.E.T.A. (for the transport of passengers and freigth) and in Italy with I.N.T. (for the transport of freight). In fact, such a mission cannot be carried out with sufficient efficiency, or with enough authority by one of the traditional departments of the railway whose officials cannot, as a rule, free themselves sufficiently from the methods and preoccupations of the railway, or have not enough time nor the necessary independence to devote themselves to such problems.

Finally, the authorities themselves cannot disassociate themselves from the problem of coordination, certain aspects of which are still very serious. Amongst these, there are two points in particular which should receive their attention :

In the case of passenger traffic, that of services parallel to the railway and that of regular or semi-regular tourist services : regular lines of tourist services, shuttle services, regular circuits. The railway administration should in every case retain commercial mastery for all parallel services. As for the other services mentioned, they should preferably be entrusted to the railway's associated companies or at least to firms that have concluded an agreement with the railway (an agreement the scope and bases of which can be, as we have seen, extremely varied and adapted to every circumstance) or which work in conjunction with the railway.

In the case of freight traffic, the problem of long distance transport has become of increasing importance. The problem in this case is the more difficult as private transport and mixed transport enter into this field and make its solution much more difficult. Here again, the development of the system of associated companies is of

value, but it is probable that as long as by this method a rational and organically coordinated utilisation of the two techniques remains unachieved, a certain amount of regulation and authoritative measures, which it lies outside our scope to enumerate here, will be found necessary.

Therefore, we consider that a sane and coherent policy as regards public overland transport should meet the following requirements :

a) consider public transport as a whole whose rationalisation, in the interests of the undertakings themselves, the community and the users, must be stimulated by organic coordination, by facilitating the working of the two techniques by the railway, especially by allowing the railway to participate to a great extent in road undertakings, and in particular, to set up associated companies.

b) On their side, the authorities should devote all their attention to other aspects of coordination, in particular :

— in the case of passenger traffic, that of services parallel to the railway and that of tourist services having a regular or semi-regular character;

— in the case of goods traffic, that of long distance transport which, if it develops without limit, risks upsetting for ever the equilibrium of public transport and its rationalisation.

c) Finally, on the general plane of finance and public economy, two postulates must be granted : on the one hand, the railway must be freed from the burdens laid upon it and indemnified fairly for the losses it suffers for this reason; and on the other hand, the motor services, more particularly the lorry services, should pay their due share of the road costs. These two conditions would make it possible to audit the balance sheets of the two methods of transport and obtain more easily, in the field of public transport, the distribution of the traffic between the two techniques according to the actual cost in a more realistic manner.

VI.

We submit hereafter to the discussion of the Congress the Summaries which seem to become apparent after the enquiries relative to the two reports.

SUMMARIES.

1. — Transport technique is in a constant state of evolution. For some years, and more especially since the end of the war, it has undergone deep-reaching changes.

2. — It is agreed that the use of the motor technique enables the railway :

a) to rationalise its working, and consequently reduce its costs;

b) to improve the quality of its services by offering its clients a wider and more complete range of facilities, thereby maintaining and even increasing its traffic.

3. — The railway should be treated like any other undertaking or industry by allowing it to make a wide use of the road technique. The railway cannot be required to seek after every possible way of reducing its costs and, consequently, to limit its adaptability both to modern techniques and the needs of its clients.

4. — The railway may have to resort to the road technique :

a) in the case of passenger traffic :

— on routes parallel to the railway (substituting bus services for railway services, replacing trains by motor services);

— on non-parallel routes (cross country lines, supplementary or feeder services);

— to run tourist tours combining rail and motor travel or even tours making use of motor services throughout;

b) in the case of freight traffic, for the most diverse purposes, in particular :

— delivery services;

— the transport of parcels traffic from the centre-stations;

— the transport of wagon-conveying trailers and rail-road trailers;

— the transport of containers;

— special transports;

— the transport of full loads when the railway services are replaced by lorry services or even the transport from one end of the journey to the other, if such is considered to be the most profitable.

5. — The railway should be left to decide in what cases it is advantageous for it to make use of motor or lorry services for its traffic.

6. — When the railway considers it « necessary or desirable » to make use of the road technique, different methods of operation may be used :

a) it can operate the road services under separate statutory organisation (en régie);

b) it can have them operated by private firms with which it has made a contract (charter contracts, renting of vehicles or services, partnership agreements, etc.);

c) or it can have them operated by undertakings under its control (majority share) which as a result are associated undertakings of the railway, or merely undertakings in which it has a financial interest (minority share).

7. — It is desirable in principle to make use of the method which will give the railway commercial control of the services, and at the same time guarantee its contacts with its clients.

The choice of method should depend solely upon the economic factors involved.

8. — The operating of passenger road services or freight services by affiliated companies (majority share) ensures great flexibility, and is justified by the considerable differences which exist between the two techniques (working conditions, social conditions, etc.) and the actual commercial atmosphere in which road transport has its being. With a statute similar to that granted to any other road transport undertaking, it is possible to make a clear distinction as regards responsibility and adapt the services perfectly to the needs of the users whilst assuring that control of the transport remains in the hands of the railway. In addition, the subsidiary company whilst operating its own services, can also make use of the indirect method of working by contract.

The system of subsidiary companies, allowing these to have a large measure of self-government, is also that which enables the railway to reap the greatest advantages from the economic and financial points of view, whilst at the same time giving it a better chance to hold its own against actual or potential competition, to make sure of its proper place in the present or future transport market, and to safeguard its own traffic and at the same time acquire further outlets.

The system of associated companies is also that which fits in the best with the idea of regional decentralisation.

9. — The participation of the railway in road transport undertakings by one of the methods which assure that it retains effective control whilst the autonomy of the road undertaking is safeguarded, fully realises the idea of organic coordination of overland transport. It should be fitted into the framework of a consistent and logical general policy for the traffic.

10. — In favouring the extension of railway road services by the setting up of associated road firms of a certain size, we also begin to get progressive rationalisation of professional road transport, a rationalisation which, thanks to the coordination of the activities of these subsidiary companies (communal buying, use of stock, repairs, etc.) leads to a reduction in their own costs.

11. — Consequently the railway should be given every freedom to follow methodically the extension of its road services and to have recourse to that method of operation best suited to its needs; in particular the setting up of associated companies, either by taking shares in existing firms or by buying them up, or by setting up new firms.

12. — Where such exist, legal or administrative obstacles which hinder such freedom should be done away with or at least diminished, and where there are no such obstacles, it is recommended to the railway managements to make free use of the faculties they have, both for the present and the future, in the interest of a more rational and effective operation.

13. — It is to be recommended that the administrations, in so far as they have not already done so, to :

a) set up, together with their central services, a coordination department or single road transport department, the duty of which will be to study systematically :

— the advantages and bases on which the road technique should be used;

— the possibilities of participation in self-contained road transport undertakings (operation by subsidiary companies);

— if there are no such possibilities, other methods of road operation (operation under separate statutory organisation (en régie), contracts, chartering or renting vehicles or services, etc.);

— the control of such participations or other methods of road operation.

These functions can, if need be, be delegated to an affiliated company.

b) set up, by the railway administration, a separate balance sheet for its investments in road services as well as the operating results of such services or the receipts from its participation in self-contained affiliated companies.

SECTION V. — Light Railways and Colonial Railways.

[621 .135 .4, 625 .143 .3 & 625 .215]

QUESTION 10.

Wear of rails on curves :

a) characteristics of track-laying on curve and details of the rolling stock liable to cause premature wear of the rails;

b) running effects of locomotives and motor coaches with motor bogies;

c) results of the investigations made and proposed remedies. Use of rail-lubrication processes,

by L. RIPERT,

Ingénieur en Chef, Chef du Service de la Voie et des Travaux de la Société Générale des Chemins de fer Économiques (France).

Special Reporter.

Question 10 was the subject of the two following reports :

Report (America (North and South), Australia (Commonwealth of), Burma, Ceylon, Denmark, Egypt, Finland, India, Indonesia, Irak, Iran, Republic of Ireland, New Zealand, Norway, Pakistan, South Africa, Sweden and the United Kingdom of Great Britain and Northern Ireland and the territories for whose international relations the United Kingdom is responsible), by V. VENKATARAMAYYA. (See *Bulletin* for September 1953, p. 533.)

Report (Austria, Belgium and Colony, Bulgaria, Czechoslovakia, France and French Union, Germany, Greece, Hungary, Italy, Luxemburg, Netherlands, Poland, Portugal and Colonies, Rumania, Spain, Switzerland, Syria, Turkey and Yugoslavia), by L. RIPERT. (See *Bulletin* for October 1953, p. 737.)

This question refers to the types of wear experienced with rails in curves, excluding the more general kinds such as undulating wear.

The present report covers the following parts :

— General notes on the effects observed.

— Influence of the characteristics of the track, and of certain features of rolling stock.

— Effects of the operation of locomotives and rail motor coaches with driving bogies, the special consideration of which is particularly opportune for several Administrations.

— Results of investigations and remedies envisaged for reducing this wear, particularly methods of lubricating the rails.

General observations on types of rail wear.

In curves, wear of rails by contact with the wheels has the following general characteristics :

a) *on the outer line of rails,* the inner face of the rail is subject to *lateral chamfering wear,* the angle of which, in relation to the rail centre line, varies between 20° and 30°. When wear is heavy, the chamfer becomes concave. The amount of this lateral wear can vary along rails in the same curve.

In addition, the running surface of the rails in this outer line wears vertically, and sometimes with an inclination which may be as much as 8° from the perpendicular to the track.

b) *on the inner line of rails,* the running surface of the rail is subject, principally, to *vertical wear* almost parallel to itself, sometimes with a slight hollowness and often accompanied by a spreading of the metal with the formation of burrs.

The *worn parts* usually retain a high surface finish. Binding may, however, be experienced during the passage of a pair of wheels with grinding and possibly the dropping of scrapings (filings or even shavings up to 5 mm [0.197 in.] long).

Finally, *the web* of the rail is sometimes deformed by *bending outwards*; very occasionally there are horizontal longitudinal cracks.

I. CHARACTERISTICS OF TRACK LAID ON CURVES AND CERTAIN FEATURES OF ROLLING STOCK LEADING TO PREMATURE WEAR OF THE RAILS.

A. — Influence of the characteristics of the track.

A distinction can be made between, on the one hand, the characteristics of the track when laid, and on the other, defects due to its maintenance.

1) *Chief characteristics of the track as laid.*

a) *Layout.* — The *radius* of the curve is the most important factor as regards wear. This is particularly marked in the case of curves of less than 600 m (656 yards) in the case of standard gauge and 350 m (382 yards) in the case of metre gauge lines. It is usually accepted that it varies in inverse proportion to the radius. Certain Railways however have found that the increase in wear is considerably greater than the increase in curvature.

The figures quoted by some Administrations make possible the following comparisons; by way of example, for curves of radius R and 2 R :

— Wear approximately proportional to the curvature : the rate is twice as great in the case of curves where R = 400 m (437 yards) than those where R = 800 m (874 yards) on the same standard gauge line. It is also nearly double in the case where R = 100 m (109 yards) (life 25 years) as when R > 200 m (218 yards) (life 35 to 50 years) on metre gauge lines.

— Wear approximately proportional to the square root of the curvature : on curves on metre gauge lines with heavy traffic, the rate is four times greater where R = 200 m than where R = 400 m, the loss in weight corresponding respectively to 300 and 70 g/m per million tons of traffic carried. It is also four times as great, on another metre gauge line, where R = 150 m (164 yards) (life 8 years) than where R = 300 m (328 yards) (life 30 to 35 years).

b) *Superelevation.* — This is usually calculated so as to assure the equilibrium of vehicles at a speed lying between that of the fastest and slowest trains. Its maximum value is generally 150 or 160 mm (6″ or 6 5/16″) in the case of standard gauge lines and 100 to 125 mm (3 15/16″ to 4 59/64″) in the case of metre gauge lines.

Insufficiency of superelevation for fast running may be as much as 150 and 100 mm (5.90 and 3.93 in.) for standard and metre gauge respectively, but it is often limited

to lower values. One Railway states that the maximum permissible insufficiency is fixed at a decreasing rate of 3 1/2″ to 2″ (89 to 51 mm), or 2 1/2″ to 1″ (63.5 to 25.5 mm) according to the class of line, when the superelevation increases from 0 to 6″ (153 mm) because of the greater influence of track imperfections at higher speeds. Uncompensated lateral acceleration resulting from insufficient lift has a preponderant influence on lateral wear by chamfering of the higher rail.

This is particularly so in the case of curves of certain track equipment which is traversed without reduction in speed.

Excessive superelevation during the passage of slow and heavy trains is the main cause of increased vertical wear on the lower rail.

c) *Gradients.* — On steep up-gradients, slipping and sudden accelerations can increase wear. This increase is more noticeable on steep down gradients because of the speed and effects of braking, the wheels of vehicles being more aggressive because of the oblique position taken by the vehicles.

A graph compiled by one Administration shows a comparison of the actual wear of outer rails on heavy down gradients and on slightly falling lines, the corresponding increase in the rates of wear varying from about 30 % to 50 % according to the radius.

d) *Widening of the gauge.* — Slacks given to the track (maximum 35 mm [1.37 in.] for standard gauge and 25 mm [0.98 in.] for metre gauge) to facilitate inscription of vehicles, have the effect of increasing the angle of attack of the wheels and consequently the lateral wear of the rails. They are often considered to be excessive and the general tendency is to reduce them (see further, Section IV) except in curves of very low radius where long wheelbase vehicles work.

e) *Transition curves.* — Insufficient length of a transition from straight to circular curve and excessive superelevation rise which results, cause more pronounced wear.

f) *Rail joints.* — Whilst the influence due to the relative position of rail joints and their bedding on sleepers does not appear to be clearly established, it is reported that wear has less continuity when joints are parallel than when they are staggered. The frequent repetition of joints by the use of short lengths of rail can be a cause of irregular wear.

g) *Sleepers.* — The type and spacing of sleepers may indirectly influence wear of rails in curves. Metal sleepers by giving greater resistance to spreading than do wood sleepers, retain the alignment better, but they consequently cause greater transverse forces to be set up if there are any track irregularities. Tighter fixing contributes to the maintenance of better alignment and level.

h) *Ballast.* — The type of ballast sometimes has an influence on the wear of rails; sand ballast disturbed by wind or the passage of trains may produce an abrasive effect.

The first five points above (radius of curvature, superelevation, gradient, gauge widening, transition curves) are considered to have a predominant influence.

2) *Inherent defects in track maintenance.*

The principal defects which can result in increased wear of rails, if they are not quickly corrected, are those concerning *alignment, angle of rail, gauge, tightness of fittings,* and *level.*

With regard to *alignment,* it appears to be recognised that deformation of curvature entails a variation in rail wear because of the lateral oscillations imparted to the vehicles. The following remarks have been made by several Administrations :

— a local difference in rail wear should be noticeable only if the versine variation on adjacent semi-chords of about 10 m (10.93 yards) is at least 20 %;

— lateral wear is more marked and more irregular when the difference between two neighbouring versines taken on chords of length S is greater than :

$$\frac{150\,\frac{S}{2}}{V}$$

(V being the speed in km/h);

— wear increases by about 1/2 mm (0.0196 in.) when the versines vary from 1.5 to 3.5 mm per metre (0.059 to 0.1377 in.) when R is between 120 and 250 m (131 and 273 yards) (metre gauge).

If however the variation in versine is *localised,* particularly at joints, lateral rail wear may be less marked.

Tilting of the rail outwards accelerates wear of the inner edge of the head and causes excessive inclination of the running surface.

B. — Influence of certain features of rolling stock.

1) *Features affecting the increase in angle of attack by the guiding wheel on the outer rail.*

a) *Wheelbase of motive units.* — With vehicles of large wheelbase L, this feature directly affects the obliqueness of the tyre to the rail ($i = L/2R$) and it has a correspondingly greater influence on lateral wear in curves when radius R is reduced. With bogie steam locomotives, the angle of attack of the bogie is influenced by the rigid wheelbase of the driving axles.

On the contrary, with a short wheelbase, the ratio of the axle play j in the track to a wheelbase L has a predominant influence on the obliqueness of the wheel ($i' = j/L$) and lateral rail wear may thus be greater as the wheelbase is reduced.

One Railway indicates that a wheelbase of 4 m (13 ft.) is considered best from the track point of view.

b) *Play of the axles.* — The permissible amounts of play, varying greatly between railways, may reach :

— play of the axle in the track, taking into account the gauge widening and wear of rails and tyres, 16 to 50 mm (0.63 in. to 1.968 in.);

— lateral play of the journal in the axleboxes and of the latter in the frame, 4 to 20 mm (0.157 to 0.787 in.);

— longitudinal play of the axleboxes in the axleguards : less than 1 mm to 8 mm (0.039 to 0.314 in).

The angle of attack may be increased proportionately to these amounts of play. Several Administrations have reduced the amounts to the minimum compatible with free inscription in the track.

2) *Resistance in bogies and bissel trucks.*

Recoil arrangements fitted to certain bogies and bissel trucks to avoid angular positioning on straight track may cause increased lateral wear of rails and this increases in relation to the power of recoil. Steam locomotive bissel trucks which often have greater recoil than bogies generally cause the heavier wear of the two.

Friction arrangements give rise in the main to increased lateral wear at the entrance to curves. Spring arrangements cause increased wear but it is more uniformly distributed over the whole curve.

Certain railways have noted a reduction in tyre wear of bissel trucks and bogies following an easing of the recoil arrangements.

3) *Suspension and position of loads.*

a) *Suspension of loads.* — Fully-sprung loads have less injurious effects in regard to rail wear than partly-sprung loads (see Chapter III).

b) *Position of loads.* — Swinging due to the loads being positioned towards the ends of the frame has the effect of increasing the transverse forces acting on the rail and thus increasing lateral wear.

4) *Wheels.*

a) *Wheel diameter.* — Flanges of small

diameter wheels, which produce higher stresses at the point of contact between wheel and rail and heavier shocks at points and crossings increase vertical wear.

A lower limit of wheel diameter is indicated by one Administration, which considers it desirable that the tread diameter D expressed in inches should be greater than the quotient of 0.2 times the load P on the wheel in English tons ($D > P/0.2$). Another Administration is of the opinion that wheels of 1 m (3′ 3 3/8″) diameter are too small for heavy electric locomotives.

On the other hand, large diameter wheels tend to increase lateral wear, but they are not very much used on lines with numerous curves and steep gradients.

b) *Tyre profile.* — The flanges of intermediate wheels are often reduced in thickness to facilitate inscription in curves. Sometimes, even, they are dispensed with if the width of the tread is sufficient to avoid the risk of the wheel falling inside the rail on low radius curves. On certain railways it has been noted that on engines with a long rigid wheelbase these flanges, even when reduced, can exercise considerable transverse force on the rails of track equipments.

II. EFFECTS OF THE OPERATION OF LOCOMOTIVES AND RAIL MOTOR COACHES WITH DRIVING BOGIES.

The introduction of vehicles with driving bogies (electric locomotives and motor coaches, locomotives and railcars with internal combustion motors) from 60 to less than 5 years ago, according to the Railway, has provided experience which shows very different results from these vehicles. The opinions expressed on this subject by the Administrations concerned also vary.

Comparison between motored vehicles and trailer vehicles from the point of view of rail wear.

In the absence of systematic measurement, the opinions expressed on the injurious effects of driving bogies, based mainly on the relative wear of tyres, may be summarised as follows :

a) Compared with steam locomotives, certain driving bogies are considered to be more aggressive in curves. Several Railways, however, consider that driving bogies are less injurious than steam locomotives with more than three axles without bogie or bissel truck;

b) Compared with carrying bogies, driving bogies are often more aggressive in practice because of the existence of irregularities of the track, although theoretically they are not more aggressive in a perfectly aligned and levelled curve;

c) Carriage and wagon bogies are less aggressive than the wheels of any other vehicles.

Presumed causes of increased rail wear due to driving bogies.

1. Weight on axle (at present 15-17 tons, and sometimes exceeding 20 tons on standard gauge and from 10 to 13 tons up to 19 tons on metre gauge) and particularly *unsprung* weight, such as nose-suspended motors;

2. Ratio of acceleration and speeds which are higher than those of steam locomotives;

3. Lack of synchronism between the motor torques to the axles;

4. Size of the angle of attack due to short wheelbase and play in the track, the tractive effort applied at the drawbar giving this its maximum value;

5. With 3-axle bogies, increased lateral pressure of the flange of the guiding wheel, due to the presence of an intermediate axle.

Transverse coupling of bogies, which allows a reduction in the angle of thrust of the leading wheels and regulates the running of the bogies by reducing the amount of « floating » in the track, are effective in reducing rail wear.

III. RESULTS OF INVESTIGATIONS AND REMEDIES ENVISAGED.

A. — Results of investigations.

Nature of investigations carried out and methods used.

There has been little systematic investigation of wear of rails in curves. Observations have been undertaken principally in connection with the following points :

a) the actual dimensions of rail sections by exact measurement with various types of equipment;

b) the position of the points of contact, continuous or intermittent, between flange and rail;

c) the structure of the metal, by laboratory examination, showing the hardening of the steel near the worn surfaces;

d) track gauge measurement whilst under load by recording equipment which reveals in particular slight deformation of the rail during the passage of a pair of wheels by comparison with measurements taken when the track is not under load; this may explain the excessive inclination of the running surface sometimes noticed;

e) systematic trials with hardened steel rails.

Relationship between wear and the various causes.

In the absence of a definite rule, it can only be taken that reduction in rail section increases in the main in proportion to :

— the curvature of the track (between K/R and K/R^2);

— the load and the number of axles;

— the speed of operation : one Administration states that lateral wear commences from radius R (in metres) depending on the speed V (in km/h) according to the equation $R/V \leqslant 10$;

— the angle of thrust of the leading axle.

Finally, it has been noted that the specific wear of a rail related to the tonnage working over it, decreases in proportion with the traffic; in effect, the flange pressure on a new rail is higher than on a worn rail, because of the modification of the profile and the superficial hardening of the steel. For example, the specific wear caused by the passage of the eighth ten-million gross tons was about 50 % of that caused by the first ten-millions.

Limits of wear before withdrawal of rails.

These limits naturally vary with the types of rails, but they are defined by rules which vary according to the Administration :

— for vertical wear the limit varies, according to whether it is accompanied by lateral wear, between 7 and 16 mm (0.275 and 0.629 in.);

— lateral wear is measured either horizontally at 10 or 15 mm (0.393 or 0.590 in.) below the running surface or on a line inclined at 45° to the rail centre line; the limit varies between 9.5 and 18 mm (0.373 and 0.708 in.). In the case of wear on the two faces, the permissible total reduction in width after reversal is 23 mm (0.905 in.) maximum;

— the maximum angle of lateral chamfer to the centre line of the rail is fixed by several railways : 26°, 32° and up to 34°.

These limits have been fixed on the basis of experience, taking into account the reduced strength of the rail, and much more infrequently the tendency of the flange to ride over the outer rail. On the latter point, it is only in exceptional cases that chamfering of the head has been acknowledged as a prime cause of derailment.

B. — Remedies adopted or envisaged.

1) MODIFICATION OF GAUGE AND SUPERELEVATION.

Widening of the track in curves has been reduced or suppressed by several Railways (for example, the reduction in gauge adopted by certain Railways is 10 to 15 mm [0.393 to 0.590 in.] for R = 300 m [328

yards] on standard gauge and for R = 150 m [164 yards] on metre gauge lines).

The *superelevation* on curves of certain lines where there is mainly fast running has been increased to retard wear of the higher rail; on the other hand, on lines with predominently slow and heavy traffic, it has been reduced to avoid vertical wear developing too quickly on the lower line of rails.

2) TURNING OF RAILS AND CHANGING OF SIDES.

In order to use the intact lateral face of rails worn on the inside, they are reversed end to end, by certain Railways, if they have no permanent deformation and the location allows it. Other railways do not normally use this procedure, considering that the rail is already reduced in strength to prevent it being used again in the same place.

Most railways change rails from one side to the other or relay them in track of less importance. This procedure gives satisfactory results.

Heavy wear on both faces of the rails gives them a truncated cone shape.

3) LAYING OF CHECK RAILS ALONG THE INNER LINE.

A check rail is laid along the inner line by several Railways in curves of low radius (generally between 300 and 120 m [328 and 131 yards] but in exceptional cases between 500 and 80 m [547 and 87 yards]), or only in those where excessive wear is experienced on the inner face.

The width of the flangeway, generally proportionate to the gauge of the track, varies between 41 and 92 mm (1.614 and 3.622 in.).

The check rail is laid along the full length of the curve, including the transition and sometimes it is extended a few metres along the straight section. It is fixed either without special fittings or by chairs.

The check rail has the main purpose of preventing derailment and the strengthening laterally of the track is subsidiary to this. Its efficiency in retarding wear of the outer rail is generally acknowledged.

On the other hand, it has the following disadvantages : increased wear of the rear face of rail flanges, increased track maintenance cost, additional resistance to train movement.

4) RAILS WITH A HIGH RESISTANCE TO WEAR.

In low radius curves on certain lines with heavy traffic, steel rails of ordinary quality, which are usually not so hard as tyre steel, are sometimes replaced by rails with a high resistance to wear, the hardness of which is greater than that of tyres :

— naturally hard rails of a single grade of steel, generally manganese;

— compound steel rails;

— heat-treated rails.

a) *Naturally hard rails of a single grade of steel* have a *manganese* content usually of about 0.8 % to 2 % (in exceptional cases 12 to 14 %). Tensile strength varies between 90 and 105 kg/mm² (57 to 66 t per sq. in.). Use is being made experimentally of *chrome* steels, *nickel* steels (about 2.3 Ni) and *nickel-chrome* (0.7 % Mn, 1.6 % Ni, 0.7 % Cr).

The life of steel rails with a manganese content of about 1.5 % may be five times as much as that of ordinary steel. One Administration considers that with an increased tensile strength of 1 kg/mm² (0.6349 t per sq. in.) by the addition of Mn, the life of the rail can be increased by 8 %.

b) *Compound or bi-metal rails.* — These rails, of which only the head portion exposed to wear is of hard steel (Manganese 0.8 % and Chrome 0.8 %) with a tensile strength of about 110 to 135 kg/mm² (69.84 to 85.71 t per sq. in.) are used by some Railways. Their cost price is very high but their life is 3 to 4.5 times that of ordinary quality rails; further their heterogeneous construction should, in the opinion of one

Administration, prevent the spread of cracks which may occur on the running surface.

c) *Heat-treated rails.* — The heads of these rails are tempered to give them a sorbitic or martensitic structure. The *sorbitic* rails have a resistance to fracture of between 80 and 120 kg/mm² (50 to 76 t per sq. in.) and their life is considered to be double that of ordinary quality rails.

Martensitic rails, with a tensile strength, which may be up to 150 kg/mm² (95 t per sq. in.) are very resistant to wear, their life being 3 to 4.5 times that of ordinary rails. Recent trials with rails hardened by high-frequency induction seem to have interesting future possibilities. Some Railways consider it preferable to limit heat treatment to the ends of rails.

It may be concluded that, despite their relatively high cost, as far as the methods of fabrication permit the achievement of finished products which are not subject to brittleness, risk of flaking or undulating wear, the use of these rails offers advantages in curves of low radius where rails are subject to heavy wear.

5) LUBRICATION OF RAILS.

The most usual and most efficient method of combating lateral wear of rails is the lubrication of the inner face. The radius below which rails are lubricated is very variable according to the lines and is particularly dependent on traffic density and speed of operation; it is generally between 600 and 200 m (656 and 219 yards). This lubrication is applied either directly on to the rails, or by means of the wheel flanges. It is done manually in certain cases, but more usually by equipment, either fitted to the rails or mounted on motive units.

Processes and equipment.

A. *Manual brush lubrication.*

Manual lubrication of *rails* by grease brush is done in exceptional cases on certain curves of low radius, and systematically on some Railways. Manually operated lubricating devices mounted on a trolley are rarely used.

Manual lubrication of *wheel flanges* is done by one Railway whenever a locomotive leaves a depot.

B. *Fixed lubricators.*

Equipment fixed to the outer rail at the entrance to curves, automatically emitting a lubricant (grease or oil) on to wheel flanges are operated by the passage of each wheel which depresses a piston or deflects the rail. The most used types are the « P & M », « Aladdin », « Hurcol », « Paehler » and « Racoor 4000 ».

C. *Lubricators fitted to motive units or rolling stock.*

Equipment mounted on motive units effects *lubrication of wheel flanges* of these units (air or steam ejectors, De Linon Fluhme & Cie, Bertschmann and Buchon types, or feelers such as those of the Friedmann type).

Other equipment carried on locomotives or rolling stock *lubricates either the cheek* or *the inner face of the rails* directly (Lubrovia type, those fitted to R.A.T.P. rolling stock and Diesel locomotives of the Tunisian Railways).

These types of equipment, automatically controlled by the angular displacement of the bogie in relation to the body, function only when the displacement reaches an amount higher than that obtained in curves of less than a given radius.

Advantages and disadvantages of the methods and equipment used.

Hand lubrication of rails involves labour costs which are rarely justifiable and its roughness of application must entail the risk of oil spreading to the running surface. Manual lubrication of rail flanges gives satisfactory results. Fixed rail lubricators operate with regularity but they must be multiplied if curves are numerous.

Amongst wheel flanges lubricators fitted

on motive units, pin lubrication valves (feelers) give good results; they are simple to install and to operate.

Rail lubricators fixed on locomotives or rolling stock appear to be reasonably effective and operate without failure, skidding or disturbance to electrical circuits. It is unnecessary to fit all engines; an adequate ratio between the number of trains per day and the number of engines fitted may be less than 6.

Some Administrations consider that, on lines with many curves, it is not necessary to use equipment functioning automatically below a given radius and that it is preferable to provide continuous track lubrication by simpler methods.

First costs and annual costs.

The *installation costs* of most lubricators vary within the following limits :

— Fixed lubricators : 25 000 to 50 000 fr;

— Lubricators mounted on locomotives : 75 000 to 200 000 fr.

Maintenance and *consumption charges* differ greatly according to the amount of traffic; the following figures give an indication of the range of several lubricators :

— Fixed lubricators : 15 000 to 20 000 francs/annum;

— Lubricators mounted on locomotives : 40 000 to 150 000 francs/annum.

If the lines have numerous sharp curves, it is more economical to fit the lubricators on the locomotives than on the track. One line is quoted as an example where 48 track lubricators would be necessary and where 4 locomotive-mounted sets of equipment have been sufficient; maintenance, consumption and redemption charges are, in this case, about one third of that which would be required for fixed lubricators.

Results obtained.

a) With regard to *track,* it is noted that rail lubrication has the immediate effect of eliminating scoring and grinding. Whilst there are no adequate comparative statistics regarding the effect of lubrication in delaying lateral rail wear, it may be assumed that, in a given curve under the same traffic conditions :

— the decrease in lateral wear on the outer line of rails may vary from 25 % to 50 %, and even more;

— this decrease is all the more noticeable as the curve becomes sharper. A graph compiled by one railway, metre gauge with heavy traffic, shows that if a comparison is made of rail wear in curves of $R = 200$ m (219 yards) and $2R = 400$ m (438 yards), the ratio of rates of wear is about 4 : 1, if the rails are not lubricated, and only 1.5 if they are lubricated.

Several Administrations, who have fairly long experience of rail lubrication, consider that it is essential in curves of low radius on lines with fairly heavy traffic (for R less than 400 m [438 yards] on standard gauge, and 300 m [328 yards] on metre gauge, when the gross traffic reaches 5 000 tons per day, is quoted by one of them). The annual saving in rails alone is reckoned by them at about 2 million francs per 100 km (62 miles) on a line including 5 % of low radius curves.

b) With regard to *rolling stock,* the effectiveness of rail lubrication is very marked in delaying *wear of wheel tyres,* particularly on locomotives working on lines with many curves. Tyre returning periods may, according to the figures given by some Administrations, be extended by 2 to 4 times and even 6 times. The resultant economy, allowing for maintenance, oil consumption and redemption charges, is assessed by certain of them at 20-30 %. In addition, one Railway reports that operating accidents and defects resulting from tyre wear have also been eliminated. A saving in *tractive force* must also result, because of the reduced resistance to running in curves; one Administration considers that it is about 10 %.

Rail lubrication on curves thus allows a notable retarding of tyre wear as well as rail wear; the resulting savings are consider-

able in curves of low radius with a high traffic density.

SUMMARIES.

1. — The characteristic form of wear on a rail of the outer line of curved track is a chamfering of the inner face of the head, the angle of which varies between about 20° to 30° to the centre of the rail. In addition, the running surface is worn on a plane sometimes slightly inclined towards the centre of the track.

The inner line of rail is subject to vertical wear of the running surface, on a plane almost parallel to it.

The finish of surface is usually maintained. Binding is sometimes experienced, accompanied by the shedding of flakes of metal.

2. — The characteristics of track laying considered to have the greatest influence on wear of rails on curve are :

— curvature of the track; lateral wear being particularly marked in curves with radii of less than 600 m (656 yards) standard gauge and 350 m (383 yards) metre gauge;

— insufficient superelevation with lateral wear of the outer rail; excessive superelevation for vertical wear of the inner rail;

— steep down gradients;

— excessive widening of the gauge;

— insufficiently long parabolic curves.

3. — The features of rolling stock which have a predominant influence on the wear of curved rails are principally those which affect the angle of thrust of the wheel on the rail; long rigid wheelbase, or on the contrary an insufficiently long wheelbase, total play of the axle in the track, longitudinal or lateral play of the axleboxes. lateral play of journals.

Amongst other causes of wear may be mentioned : the stiffness of some bogie or bissel side control arrangements, amount of unsprung masses, diameter of wheels. Small diameter wheels cause higher stresses and heavier hammer-blows at rail gaps than wheels of large diameter.

4. — The effects of locomotives and motor coaches with driving bogies are the object of varying views. Whilst some Administrations have not noticed any harmful results, others consider them to be particularly aggressive and to produce lateral rail wear which is much heavier than that caused by carrying bogies or by certain long wheelbase vehicles.

These effects are attributed principally :

— to the amount of the axle load and especially to the unsprung mass (particularly of nose-suspended traction motors);

— to the increased rate of acceleration and speed;

— to asymmetrical motor couple.

They show themselves particularly in track irregularities.

5. — As the factors which influence the wear of rails in curves are numerous, it is difficult to separate any one of them from the whole. The quality of maintenance must also be taken into account.

It is generally admitted that the reduction in rail section, in a curve of radius R, increases as a function of :

— the curvature, in a proportion between $\frac{K}{R}$ and $\frac{K}{R^2}$;

— the axle load and the speed of operation;

— the angle of thrust of the guiding axle.

6. — The limits of lateral wear and that on the running surface have been established on the basis of experience, taking into account the reduced strength of the rail.

It is only in exceptional cases that chamfering of the worn head of the outer rail has been admitted as a decisive factor in derailments caused by the flange mounting the rail.

7. — To combat wear of rails in curves, the following methods are adopted :

— reduction in widening of the gauge, and modification of the superelevation;

— laying of a check rail along the inner line;

— use of rails with a high resistance to wear;

— lubrication of rails.

On several Railways, the life of rails is extended where one lateral face of the head is worn by reversing them end to end, by changing them over to the other line of rail, or by relaying them in tracks of less importance.

8. — The degree of gauge-widening given to track has been reduced on some lines, with the aim of lowering the angle of thrust and reducing oscillation, as far as compatible with the free inscription of vehicles in the curve. Attempts have been made to achieve a closer relationship between superelevation and operating speeds.

9. — A check rail is sometimes laid along the inner line of certain particularly sharp curves, but this seems to be essentially a safety measure. The check rail has, in fact, the drawbacks of causing supplementary wear on the inner surface of tyres and increasing resistance to movement.

10. — Rails of steel with a high degree of resistance to wear are used by some Railways in low radius curves of lines with heavy traffic : naturally-hard rails of a single grade of steel usually manganese — composite steel rails in which only the portion of the head subject to wear is of hard steel — heat-treated rails (sorbitic or martensitic).

These rails give a greatly increased life, 2 to 5 times that of ordinary quality steel. Their higher price, however, often prevents their use being extended.

11. — Lubrication of the inner face of the head on the outer line of rail is at present used by numerous Railways.

Manual lubrication, limited to special cases because of the labour cost involved, must be carefully done to avoid the spread of oil on to the running surface.

Several types of fixed lubricators and equipment mounted on motive units or trailer vehicles provide a satisfactory regularity of operation.

The use of lubricators fixed to the rail at the entrance to curves, worked by the passage of each wheel, is particularly justified on isolated curves of low radius, or where the curves are relatively few in number.

Equipment fitted to motive units or trailer vehicles, either lubricating the rails directly or the wheel tyres, are more economical than the above on lines which include fairly numerous curves. This lubrication can be continuous on very sinuous lines, but is usually automatically restricted to the entrance to low radius curves.

Rail lubrication provides a very efficient means of reducing not only their lateral wear, but also tyre wear. The life of rails is, in certain cases, almost doubled.

[621 .33]

QUESTION 11.

Protection of overhead lines, substations, locomotives and motor coaches against accidents of electric nature (excess voltage, overloads, short circuits and lightning...),

by J. F. M. De Boeck,

Ingénieur en Chef au Service Technique de la Société Nationale des Chemins de Fer Vicinaux, Bruxelles,

Special Reporter.

The object of the present Report is to summarise the 2 following Reports relative to Question 11 :

— Report (America (North and South), Australia (Commonwealth of), Burma, Ceylon, Denmark, Egypt, Finland, India, Indonesia, Irak, Iran, Republic of Ireland, New Zealand, Norway, Pakistan, South Africa, Sweden and the United Kingdom of Great Britain and Northern Ireland and the territories for whose international relations the United Kingdom is responsible), by T. S. PICK, B. Sc. (Eng.), (See *Bulletin* for November 1953, p. 887).

— Report (Austria, Belgium and Colony, Bulgaria, Czechoslovakia, France and French Union, Germany, Greece, Hungary, Italy, Luxemburg, Netherlands, Poland, Portugal and Colonies, Rumania, Spain, Switzerland, Syria, Turkey and Yugoslavia), by J. F. M. DE BOECK. (See *Bulletin* for February 1954, p. 191.)

INTRODUCTION.

§ 1. Scheme of the Special Report.

The author has followed the scheme he had adopted for the report on the French language zone. One may find it somewhat arbitrary under certain aspects. For instance, the protection of the transformer cannot logically be separated from that of the convertor. Likewise, the essential object of the protection against excessive heating is the protection against overloads. The only aim of the choice of the scheme is a more systematical classification of the *methods* of protection.

The indexation of the headings has been completed by a reference to the questionnaire : letter Q followed by the number of the corresponding question(s).

The summaries have been assembled at the end of the report, in order to make their examination easier.

§ 2. General considerations.

1. We believe that all essential protections have been treated : indispensable protections that were not dealt with by the questionnaire, have not been pointed out to us.

2. The distinction between voltage surges originating in the installations themselves, on the one hand, and those caused by atmospheric electricity, on the other hand, does not appear to be justified in practice.

3. The general conclusion of Mr. Pick on the subject of protection against overloads should be taken into consideration. A protective system which at the same time, gives a sufficient security and allows to take full advantage of overload capacities, does not exist.

* * *

CHAPTER 1.

PROTECTION OF HIGH-TENSION DISTRIBUTION SYSTEMS.

Note : These are understood to comprise the generating equipment and the installations for power transportation between the generating points and the utilisation points, including H.T. bus bars.

* * *

The relay types of current manufacture seem to give satisfaction.

The installation of protective devices peculiar to primary bus bars appears to be relatively rare. The reporters think it recommendable to provide such a protection, as well for substation bus bars as for bus bars of distribution points.

In order to obtain an adequate protection of the installations, bus bar protection should include overcurrent relays, eventually combined with earth fault relays; in this respect, relays of the differential type are not sufficient.

* * *

CHAPTER 2.

PROTECTION OF STATIC TRANSFORMERS.

21. Overloads and short circuits (Q. 17 and 18).

The ideal protection consists of a group of two devices which control the tripping of the primary circuit breaker :

a) by an instantaneous overcurrent element, to guard against the destructive effects of heavy short circuits;

b) by a device which includes an element whose temperature would reproduce that of the *hottest spot* of the windings.

The technique has solved the first problem to an acceptable extent by the instantaneous overcurrent relays. As a matter of principle, direct overcurrent trips should be preferred to relays connected to current transformers, because the former act more rapidly.

The solution of the second problem mingles with the protection against excessive heating, examined under heading 22.

22. Excessive heating (Q. 19).

Theoretically, it is the « *thermal image* » (1) which permits to utilise to the greatest possible extent the overload capacities of a transformer. It may therefore be said to give the most adequate protection.

The devices of this type appear to be well-adjusted technically; they are, however, of a comparatively recent design, and only two Administrations have explicitly stated that they use them.

It would therefore be premature to conclude that they are absolutely efficient. However, they are to be taken into consideration, if there be any reason to take full advantage of heating capacities.

Overcurrent time delay relays assure an acceptable protection for all practical purposes. Thermal relays of this type are rarely mentioned. They do not appear to present any marked advantage.

For oil-immersed transformers, the use of contact thermometers, measuring the oil temperature, or thermostats gives a supplementary protection. It may be admitted that overcurrent time delay relays are no longer essential if these are employed.

23. Voltage surges (Q. 20).

This heading deals with the protection against voltage surges occurring on the primary of the transformers. For those manifesting themselves on the secondary, see heading 325.

In the English language zone, the Administrations who have sent replies do not assure the protection against these incidents, barring one partial exception : *New Zealand Gov. Railways.*

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(1) Cf. report for the English language zone, heading 222, p. 195/41.

In the French language zone, the use of surge arrestors is far from general. On the other hand, there is a great diversity in the types employed. The Administrations did not justify their choice.

We conclude that no H.T. surge arrestor offers a completely reliable protection and that their installation is not indispensable, especially when other devices exist (earth wire on overhead distribution lines, shock coils on transformer windings).

24. Various incidents (Q. 21).

241. Internal damage to oil-immersed transformers.

All the transformers noted in the French language zone, and some of the *Railway Board - Gov. of India* are equipped with Buchholz relays.

On the *New Zealand Gov. Railways* and the *British Railways* their installation is under consideration. One may say, therefore, that there is a general tendency towards the use of this relay.

242. Failure of cooling fan (transformers with air-blast cooling).

It is logical to install a protective device in the air stream, as is done by *London Transport Executive* (for details cf. Mr. PICK's report, Q. 19 *a*).

* * *

CHAPTER 3.

PROTECTION OF STATIC CONVERTORS.

31. Overloads and external and internal short circuits (Q. 23 and 28).

Note : Internal short circuits are understood to be arc-backs.

I. Convertors with several vacuum enclosures.

An acceptable protection is assured by the combination of :

a) overcurrent relays or trips actuating the unit H.T. circuit breaker;

b) high-rupturing capacity anode fuses.

Note : These fuses may give rise to important replacement costs. For D.C. tensions of 1.5 kV, they have caused serious trouble. One may therefore be induced to prefer anode current relays.

An individual overcurrent cathode relay for each convertor is recommendable. It will guard against an unequal repartition of loads on convertors of one unit. The cathode relay shall be arranged to trip the unit H.T. circuit breaker, and it is also desirable that it disconnects each convertor element from the D.C. bus bars.

II. Convertors with a single vacuum enclosure.

Four conclusions may be drawn from the replies received :

1. In the French language zone the custom of providing unit H.T. circuit breakers with time delay and instantaneous overcurrent devices (overloads and short circuits) seems to prevail.

Generally speaking, the opinions of the consulted manufacturers corroborate this practice.

Two important Administrations (*Soc. Nationale des Chemins de fer Français* and *N.V. Nederlandsche Spoorwegen*) however, content themselves with an instantaneously-acting device. In that case it is indispensable to provide thermostats (cf. 321).

There is little or no unity in the appliances used in the English language zone. However, barring one exception (*British Railways, Southern Region*), overcurrent time delay relays are used.

2. Anode fuses are little used with steel tank rectifiers.

3. Where no anode fuses are installed, a high-speed reverse-current circuit breaker is necessary, if there is a possibility of backfire. That is to say, in fact, almost always.

4. Arc-suppression equipment seems to be recommendable for tensions of 1 to 1.5 kV (D.C.) or more, or if high power units are involved.

Note : In the English language zone,

arc-suppression gear appears to be less used than in the French language zone. British manufacturers who were consulted have shown themselves rather reticent, with regard to its use.

It must be pointed out that arc-suppression gear does not assure a perfect protection, and that its presence does not dispense with a reverse-current circuit breaker.

32. Other incidents (Q. 23 to 27 and 30).

Preliminary remark : GLASS BULBS.

On the *British Railways, Midland Region,* the protection of glass bulbs is limited to overloads and short circuits. *New Zealand Gov. Railways* also reduce the number of protective appliances.

321. Excessive heating (Q. 23).

On steel tank rectifiers, *thermostats* are currently used. They either :

a) give a warning signal;

b) actuate or control the cooling system (air or water), or

c) shut down the unit.

These thermostats are necessary wherever no other protection against overload exists.

322. Failure of cooling system (Q. 24).

The most rational protective device controls the circulation of the cooling medium (water or air).

In the case of air-blast cooling, the most logical device appears to be the « ventilation pallet ».

323. Ignition or excitation failure (Q. 25).

1) For non-attended substations, the shutting down, at least temporary, of the rectifier unit, is necessary.

For attended substations, an alarm system may be regarded as sufficient.

2) As a rule, the active element will be a current relay.

324. Loss of vacuum (Q. 27).

(Convertors with continuous pumping.)

The electrical vacuum meter is frequently used. Certain Administrations think it unnecessary or rather inefficient.

Its action shall be the same as for ignition or excitation failure (point 1, heading 323).

325. Voltage surges (Q. 26).

A surge arrestor is generally installed on each anode.

The most various types are being used, and no preference for one or another has been marked out, probably because no elements of comparison were available.

326. Various incidents (Q. 30).

Earth leakage relays, connected between the steel frames supporting the apparatus and the negative bus bar or the earth plates (or spikes) may be mentioned (*R.A.T. Paris, Soc. Nationale des Chemins de fer Français, South African Railways*).

For tensions of 1 kV D.C. or more, a protection has to be provided.

33. Automatic voltage control (Q. 29).

Automatic voltage control is rarely practised, probably because of its complexity.

* * *

CHAPTER 4.

PROTECTION OF CONTACT LINES AND OF THEIR POWER SUPPLY FEEDERS.

41. Constitution of the railway systems (Q. 31 to 34).

(For memory — the constitution of the railway systems hardly influences the forms of protection.)

42. Overloads and short circuits.

421. Track circuit breakers and accessories (Q. 39, 40 and 42).

A) *A.C. systems.*

No conclusion, for want of a sufficiently comprehensive documentation. The use of high-speed circuit breakers is to be noted (tripping time of the order of one-half cycle).

B) *D.C. systems.*

1. The use of high-speed circuit breakers should be recommended.

2. High-speed circuit breakers, having a very short tripping time, obtained by the action of a magnetic field generated by the main load current, in opposition with the field of a holding coil, should be recommended. It would be useful that these circuit breakers be made sensible to short circuits by providing them with a magnetic shunt.

3. If the usual load of the feeder tends to cause a rise of temperature such that it approaches the admissible limit, the addition of a thermal device, having characteristics suited to the load, and controlling the tripping of the circuit breakers, should be considered.

The *London Transport Executive* install excessive cable temperature indicators (cf. report for the English language zone, Q. 40).

422. Automatic line tests (Q. 41).

Automatic re-closing on faulty lines is more frequent (i.e. more esteemed) in the English language zone than in the other.

The most usual criterion for re-closing is a limited number of successive re-closings in a given space of time.

The more reasonable criterion, according to which the re-closing is subject to an automatic test of the line resistance, is being criticized by certain Administrations using direct current at 1.5 kV or more (uncertain working or prohibitive cost of apparatus).

The Administrations, who apply the latter system under A.C., or D.C. of approximately 0.6 kV, do not complain about it.

We infer that the good working of that kind of apparatus depends on contingencies and probably on the form of its realisation.

43. Voltage surges (Q. 43, 44, 48 and 49).

Note : The protection of contact lines and of vehicles will be treated simultaneously.

One cannot fail to observe discordances and a diversity that are astounding at first sight. Thus, in the French language zone, surge arrestors based on the properties of semi-conductive substances prevail for the protection of overhead lines, whilst appliances of the condenser type (of the order of 4 microfarad) outweigh other types on the vehicles. The latter are almost always protected.

On the other hand, the condenser type or electronic arrestors are much more in use for the protection of overhead lines in the other zone. With respect to vehicles, Administrations in Great Britain content themselves with a rather summary protection.

It is therefore impossible to draw general conclusions. One should not expect so either : in outdoor installations, troubles are caused chiefly by voltage surges of atmospheric origin, and their frequency and intensity are subject to climate and local circumstances. There is, nevertheless, a tendency towards the use of condenser type arrestors on D.C. systems.

44. Parallel operation of substations (Q. 35 to 38).

We recall to mind the two principal disadvantages of this way of supplying power to the lines :

a) Shutting down of several sections in case of damage to one of them;

b) Increased probability of prolonged feeding into a fault presenting a comparatively high electrical resistance (distant

short circuit); it is known that this accident may cause serious damages.

We conclude that :

1) The advantages of parallel operation heavily outweigh its disadvantages.

Its application should therefore be recommended, except when it is impossible or when serious trouble on the power distribution system would follow (e.g. : *a*) cf. Mr. Pick's report, Q. 36, p. 904/18, *London Transport Executive*; *b*) Mr. De Boeck's report, p. 203/49, heading 440, *Bas-Congo-Katanga*).

2. Various appliances enable us to guard against the two disadvantages mentioned above (or against one of them), by taking full profit of the characteristics of the substation and switching station circuit breakers, of by mutual control of their tripping devices.

Note :

To our knowledge, a device which, under all working circumstances, can be relied upon to give a secure and specific protection against electrically resistant faults, does not exist.

Some appliances, however, seem to bring about some additional security.

* * *

CHAPTER 5.

PROTECTION OF ELECTRIC MOTOR VEHICLES.

51. Main or overall protections.

5111. Overloads and short circuits (Q. 47).

A. — *A.C. systems.*

No element permitting to draw a general conclusion has been marked out.

B. — *D.C. systems.*

1st category : tension of the order of 3 kV.

The use of high-speed circuit breakers controlled by overload relays and eventually by differential relays is to be recommended.

Note : Line contactors combined with plain circuit breakers and fuses [1] present economical advantages, according to the *Ferrovie dello Stato.*

2nd category : tension of the order of 1.5 kV and less.

In most cases, ordinary circuit breakers with plain overcurrent trips, and even fuses, assure an acceptable protection.

5112. Voltage surges (Q. 48 and 49).

Cf. heading 43.

5113. Other incidents.

On powerful units, and especially for D.C. tensions of the order of 1.5 kV and more, it is desirable to provide no-volt trips.

52. Secondary circuits.

No outstanding element to mention .

* * *

CHAPTER 6.

REGENERATIVE BRAKING.

60-61. General considerations.

This means of braking is only applied in special cases. The supplementary apparatus which this application calls for does not appear to set up any insuperable difficulty, with regard to the protection. The appliances ad hoc do not present any notable particularity. Their operation may be considered as satisfactory. The equipment is rather expensive.

611. Absorption of regenerated current at the substations (Q. 51b and 52).

Only four Administrations make provision for it, viz. :

A. — *On rotary convertors :* the *C.F. Algériens,* the *C.F. Maroc* and the *Railway Board - Gov. of India (Southern Section).*

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[1] Cf. report for the French language zone, rubric 5111 B : *Ferrovie dello Stato :* « séparateur de protection ».

B. — *On static convertors :* the *South African Railways.*

— No difficulties have been mentioned.

612. **Regenerative braking on the vehicles (Q. 51a and 52).**

The protection should conform to the following essential conditions :

1°) A safe and efficient means of braking must be available under all circumstances. The alternative braking must be able to work *in a very short time,* should the possibility of regenerative braking disappear.

2°) The regenerative braking may not be put into operation unless a sufficient amount of regenerated current can build up on the vehicle in question.

3°) Any over-voltage must be prevented.

* * *

SUMMARIES.

Protection of high-tension distribution systems.

I. — The relay types of current manufacture assure an acceptable protection.

II. — 1) The protection of each point of distribution, including traction substations, is recommended.

2) In order to obtain an adequate protection of the installations, the protection should include overcurrent relays, combined with earth fault relays; in this respect, relays of the differential type are not sufficient.

Protection of static transformers.

III. — The ideal protection against overloads and short circuits consists of a group of two devices which control the tripping of the primary circuit breaker :

a) by an instantaneous overcurrent element;

b) by a device which includes an element whose temperature would reproduce that of the hottest spot of the windings.

IV. — Theoretically, it is the « thermal image » which assures the most adequate protection against excessive heating.

V. — Overcurrent time delay relays assure an acceptable protection for all practical purposes. Thermal relays of this type do not present any marked advantage.

VI. — For oil immersed transformers, the use of contact thermometers measuring the oil temperature or thermostats gives a supplementary protection.

VII. — No H.T. surge arrestor offers a completely reliable protection. Their installation is not indispensable, especially when other devices ad hoc exist (earth wire on overhead distribution lines, shock coils on transformer windings).

VIII. — There is a general tendency towards the use of the Buchholz relay as a protective device against internal damage to oil immersed transformers.

IX. — It is logical to install a protective device in the air stream of the air cooled transformers.

Protection of static convertors.

X. — For convertors with several vacuum enclosures, *complete* protection against overloads and short circuits (external and internal) is assured by the combination of :

a) overcurrent relays actuating the unit H.T. circuit breaker;

b) high-rupturing capacity anode fuses or high-speed overcurrent anode relays;

c) an individual overcurrent cathode relay for each convertor. This will be arranged to trip the unit H.T. circuit breaker and disconnect the convertor from the D.C. bus bars.

XI. — *a*) For convertors with a single vacuum enclosure, it is recommended for the protection against the overloads and short circuits to use the H.T. circuit breaker with time delay and instantaneous overcurrent devices;

b) Anode fuses are little used with steel tank rectifiers;

c) Where no anode fuses are installed, a high-speed reverse-current circuit breaker is necessary, if there is a possibility of back-fire;

d) Arc-suppression equipment seems to be recommendable, for tensions of 1 to 1.5 kV or more, or if high power units are involved.

XII. — In order to protect steel tank rectifiers against excessive heating, *thermostats* are currently used. They either :

a) give a warning signal;

b) actuate or control the cooling system (air or water), or

c) shut down the unit.

These thermostats are necessary wherever no other protective devices against overload exist.

XIII. — The most rational protective device against a failure in the cooling system controls the circulation of the cooling medium (water or air).

XIV. — The protections against ignition or excitation failure are : the shutting down, at least temporary, of the rectifier unit; however, for attended substations, an alarm system is sufficient.

XV. — For convertors with continuous pumping, it is necessary to protect against the loss of vacuum. The action should be the same as for the ignition failure.

XVI. — A surge arrestor is generally installed on each anode.

XVII. — Automatic voltage control is little or rarely practised because of complexity.

Protection of contact lines and of their power supply feeders.

XVIII. — High-speed circuit breakers are used for both A.C. and D.C. systems as a protection against overloads and short circuits.

XIX. — The protection of contact lines against voltage surges is a matter of local circumstances.

The tendency is to use an electronic surge arrestor or condenser.

XX. — The disadvantages of the parallel operation of substations can be taken care of by means of a combination between the characteristics of the circuit breakers in the substations and in the switching stations.

Protection of electric motor vehicles.

XXI. — On D.C. systems of 1.5 kV and less, ordinary circuit breakers are used for the protection against overloads and short circuits. Fuses are also used.

On D.C. systems of $\pm$ 3 kV, high-speed circuit breakers, controlled by overload relays, are used. Differential relays are extensively used.

XXII. — On D.C. systems the protection against voltage surges, when provided, is in general realised by means of devices with condensers.

XXIII. — On powerful units, and especially for D.C. tensions of the order of 1.5 kV and more, a no-volt tripping is normally provided.

Regenerative braking.

XXIV. — The protection should conform to the following essential conditions :

1°) A safe and efficient alternative means of braking must be available under all circumstances. This braking must come into operation *in a very short time*, should the possibility of regenerative braking disappear;

2°) Any over-voltage must be prevented.

* * *

ADDENDUM.

The reply of the « Red Nacional de los Ferrocarriles Españoles » has reached us on the 18th January 1954.

We have not found in it any indication invalidating the above summaries.

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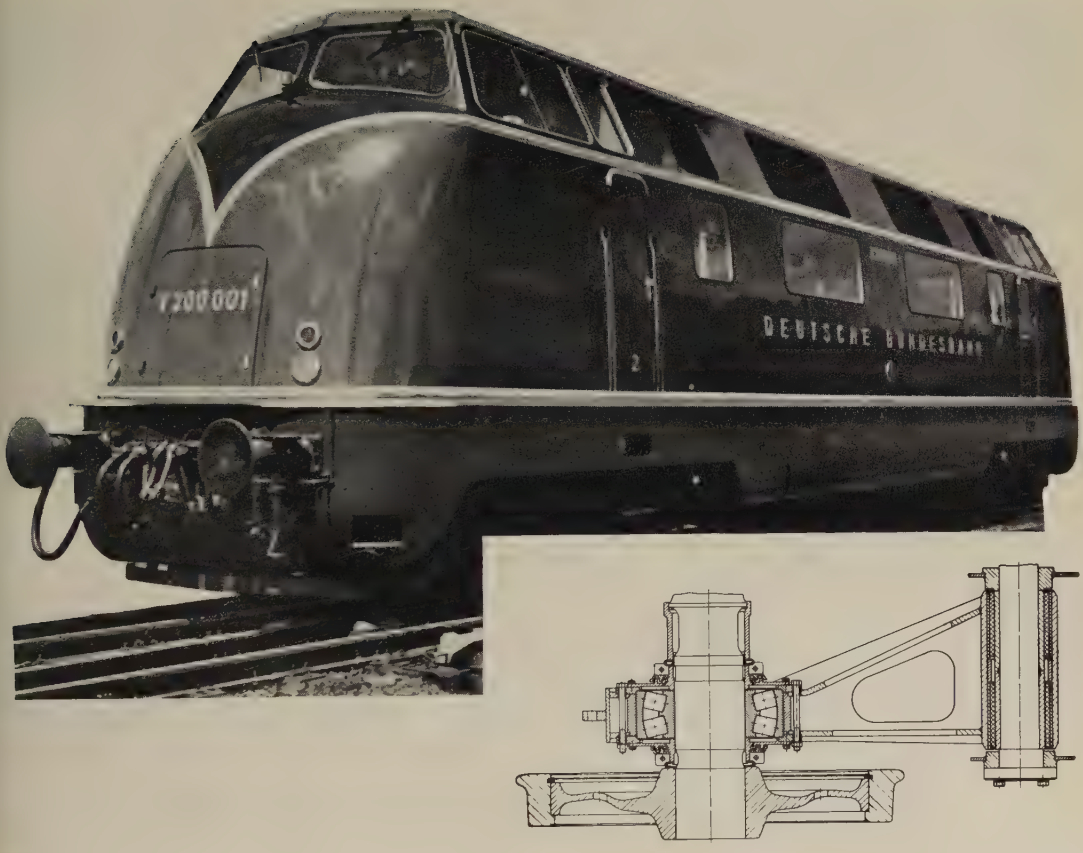

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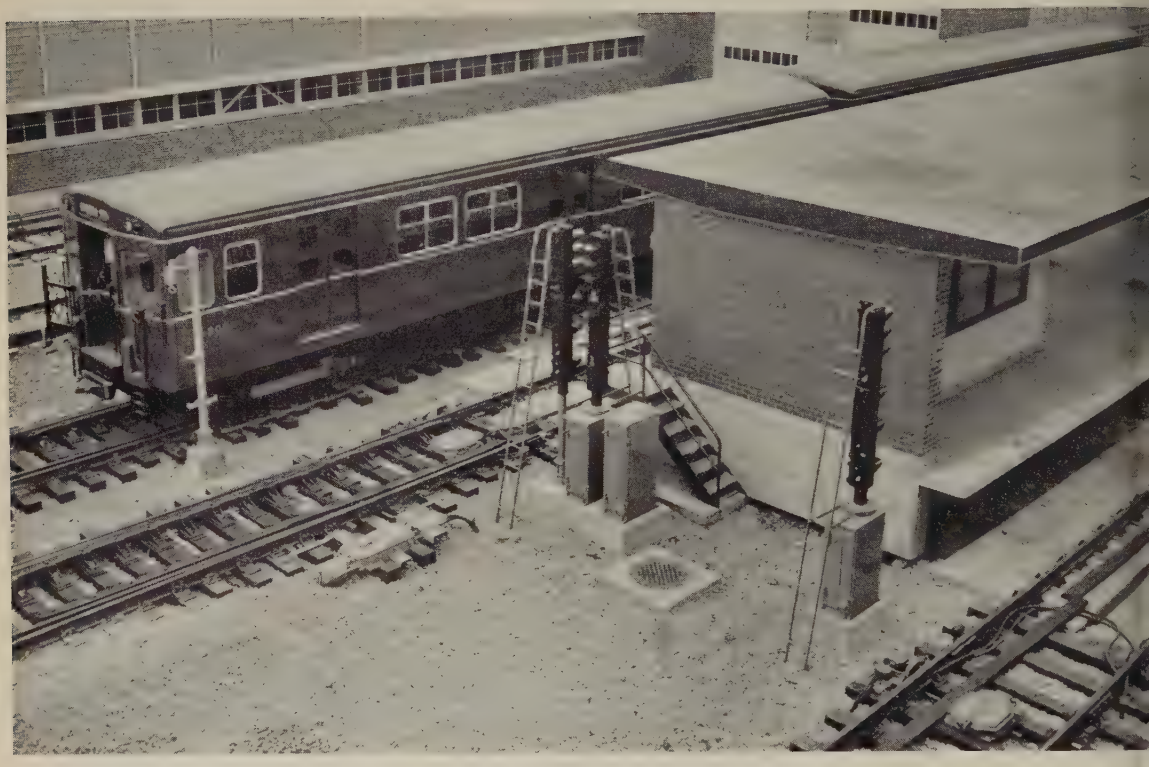

View from signal tower at Davisville, Toronto Transit Commission

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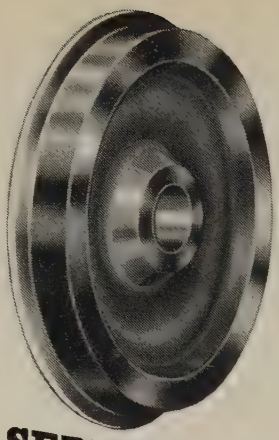

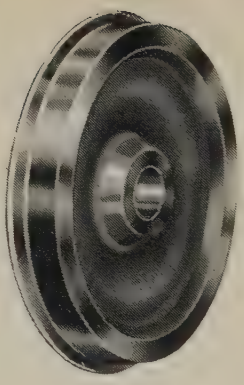

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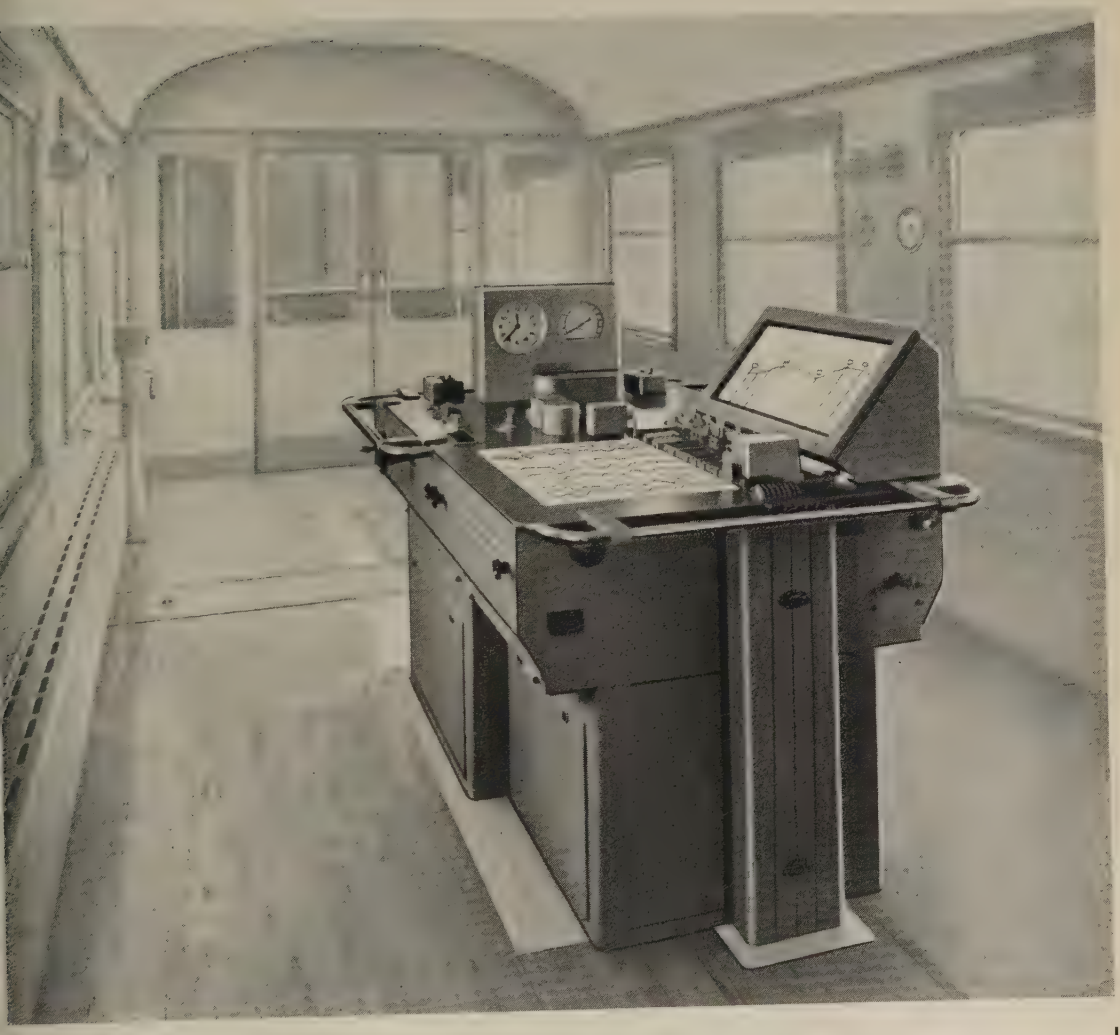

Track Inspection Car. Apparatus room. View from front.

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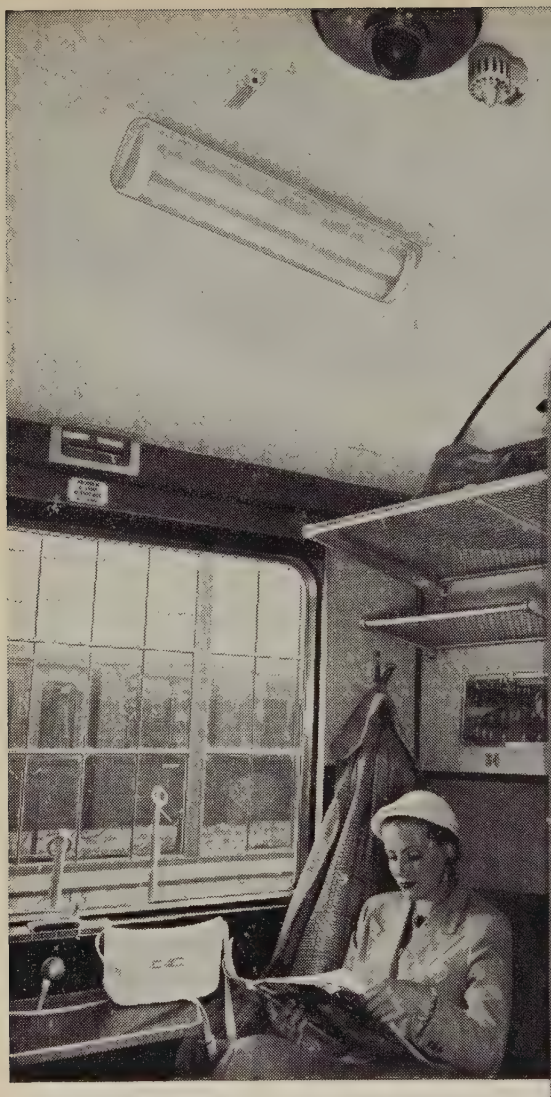

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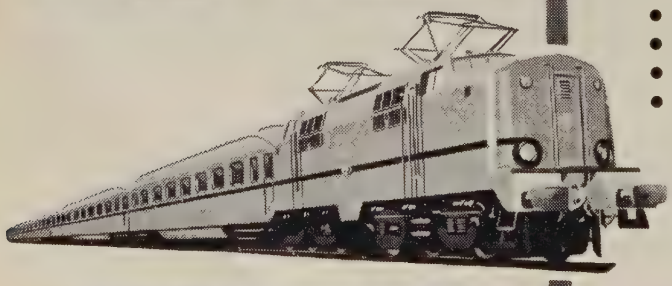

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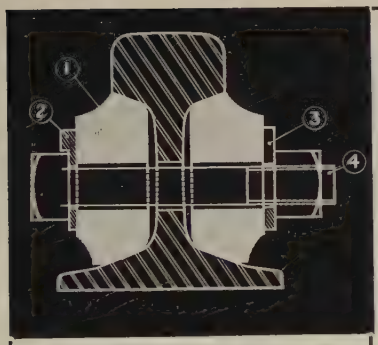

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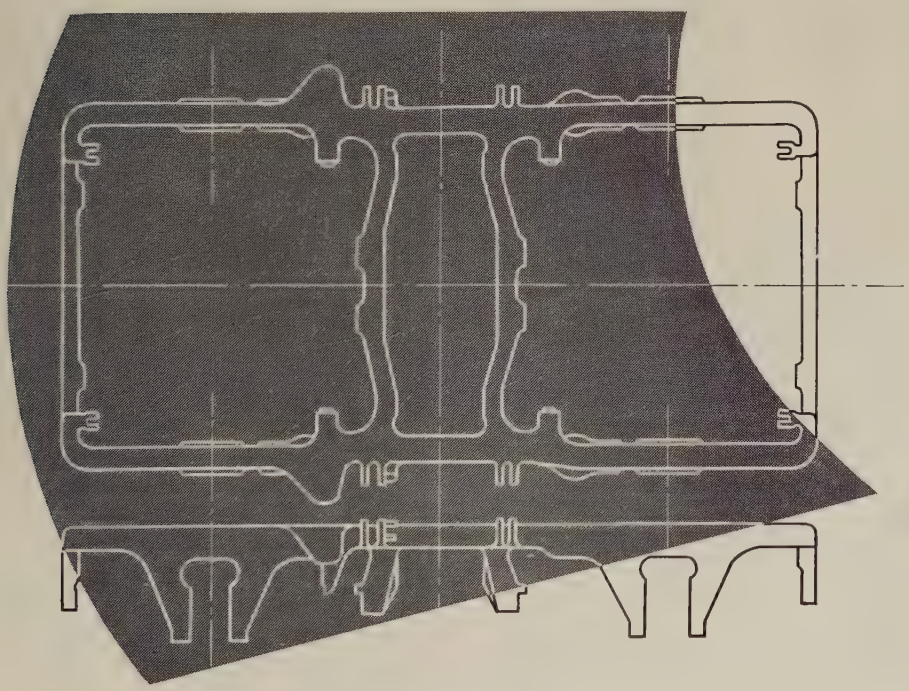

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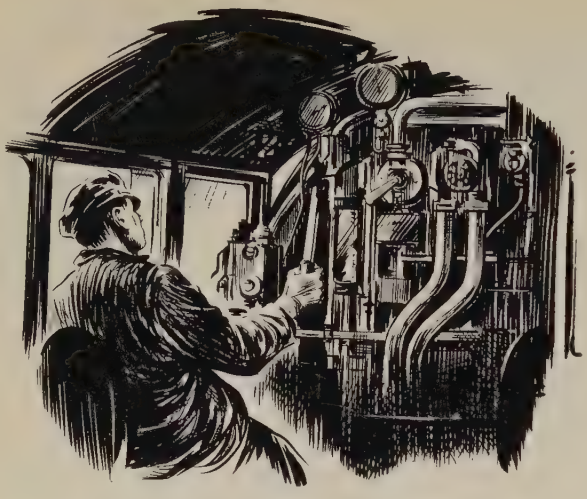

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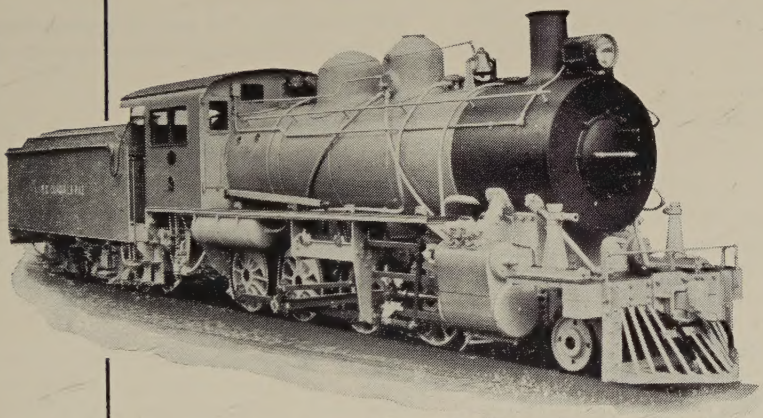

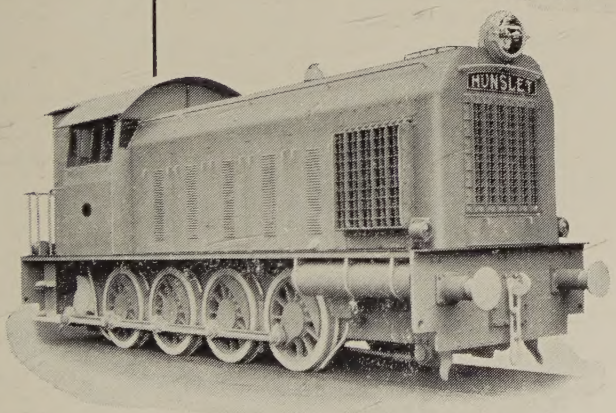

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